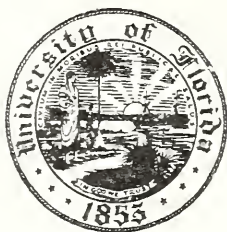






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GENERAL PSYCHOLOGY
FOR COLLEGE STUDENTS



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GENERAL PSYCHOLOGY

FOR COLLEGE STUDENTS

By

CARL NEWTON REXROAD, PH. D.

PROFESSOR OF PSYCHOLOGY
STEPHENS COLLEGE

New York

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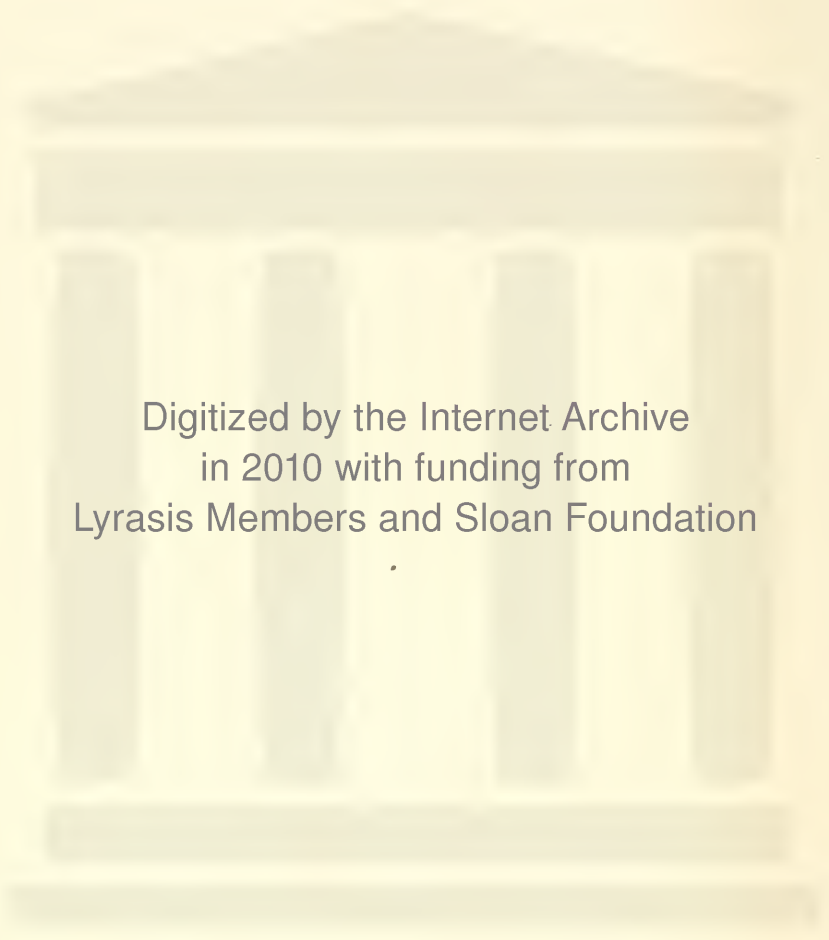


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To
MY WIFE



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PREFACE

Each branch of science is engaged in the investigation of a definite set of problems. As it collects data, it re-formulates its interest, re-defines its tasks, and re-interprets data previously collected. Psychology in the last few decades has been undergoing a major transition in point of view and interest. This newer point of view is usually termed behavioristic, since those adopting it are interested in the description and explanation of human behavior, particularly that behavior which is socially significant. Conceiving this to be the central interest of present-day psychology, I have in this book but one aim, to help the student to an understanding of his behavior and that of others. The choice of material, the order of development, and the terminology used have been determined by this aim.

In Chapters 1 and 2, I have attempted to derive through an examination of scientific principles the assumptions which underlie the behavioristic point of view and to deduce from these assumptions the problems or tasks with which psychology is confronted and the sort of data which is needed in solving these problems. Chapters 3, 4, and 5 are intended to present those biological and physiological concepts which throw most light upon the problems of human behavior. In them I have emphasized the concept of metabolic gradient as developed by Child and others. In Part Two, I have endeavored first to bring out the fundamental principles of maturation and learning, and then to describe the development of behavior in the light of these principles. It seems to me that the central problem of psychology is that of learning, that of describing how we as infants become adults behaving in such a manner that we fit ourselves into the complex civilization in which we live, and I have, therefore, attempted to give special emphasis to the treatment of development in behavior. Part Three is concerned

with the more important characteristics of adult behavior as they are exhibited in everyday living. This part logically divides itself into two sections, the discussion of common characteristics and the treatment of individual differences. Psychologists will recognize in it a re-interpretation of much data collected by non-behavioristic schools of psychology, but my interest has been primarily to picture adult behavior in the light of Parts One and Two rather than to deal with the interrelations of the various schools of psychology. My efforts in these directions are my excuse for offering another textbook in the field of psychology.

Since the book is designed for class-room use, it is intentionally concise in style. A text, in my opinion, serves to raise the problems of the field in their logical order, to mark out and illustrate the solutions of the problems, to give the general applications of the principles developed, and to stimulate the student to trace out the ramifications of the problems through collateral reading and in his own thinking; while the instructor functions in amplifying, adding illustrations, making specific applications, stimulating and guiding further study and discussion.

The references at the end of each chapter list for the most part books rather than original articles. It is felt that for the beginning student collateral reading which summarizes and interprets investigations is more profitable, although I believe that by the end of the first course the student should know how to find references to original articles and should be able to read intelligently a large proportion of them.

To the student I should make the following suggestions with reference to study. (1) For those students who have not learned to transpose automatically topic headings into questions, it will, I believe, be worth while to practice this transposition, even to write out a set of questions as suggested by the topic headings of each chapter. An attempt has been made to emphasize the outline of each chapter through proper captions, and special attention to these will be helpful. (2) I would further suggest that

the student prepare and keep two lists, one of new words and their definitions, and one of important principles, concepts, and generalizations.

My indebtedness to my wife for her constant aid and for her criticisms of form and content is expressed elsewhere.

I have profited so much from my association with Dr. A. P. Weiss while he was my senior colleague at Ohio State University and from his book, *A Theoretical Basis of Human Behavior*, that it is fitting to make special acknowledgment of his influence. I should also mention the help and encouragement received from other former colleagues and the criticisms of graduate students and those students in the classes in which preliminary drafts of the material were used in mimeographed form.

To Dorrice R. Morrow I am indebted for her careful and critical reading of the galley and page proofs, to Dr. T. A. Zunder and Mabel A. Buckner for criticisms of parts of the manuscript in regard to grammar and style, and to Louise Trautman for help in preparing the illustrations.

I take pleasure in acknowledging also the courtesy of the following authors and publishers for permission to use quotations and reproduce illustrations: E. L. Thorndike, Henry Holt and Company, Houghton Mifflin Company, W. B. Saunders Company, P. Blakiston's Son and Company, J. B. Lippincott Company, and the Children's Bureau of the U. S. Department of Labor.

CARL NEWTON REXROAD

STEPHENS COLLEGE
COLUMBIA, MO.
JULY, 1929

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PART ONE
THE PRINCIPLES OF BEHAVIOR

CHAPTER 1

SCIENCE

Science is man's attempt to understand the universe and all things in it. In this undertaking there is division of labor, a form of co-operation that results in the many branches of science, among them psychology. Each of these has its own tasks more or less sharply set off from those of other branches. The problem of psychology is to understand human behavior. The psychologist wishes to learn how people act under various conditions and why they act as they do. He wants to understand the origin of our likes and dislikes, our fear and courage, our hopes and ideals, how we develop skills in the manipulation of the things of our environment, how we come to gather information that helps us and can be passed on to others, how we think and how it comes about that we think as we do, in short, how we as infants become adults behaving in such a way as to adapt ourselves to the complex civilization of today.

This endeavor to understand human behavior grows out of practical needs just as do the efforts in other branches. The physician must have a knowledge of diseases, know what effects they may have on his patients and how to make them yield to his treatment. The machinist must be familiar with his tools, know what may be done with them and how to make them do those things. The chemical engineer must understand his chemicals, know what reactions they make and how to cause them to give the products he desires. The farmer must understand his crops, what yields they should return and how to achieve a maximum harvest. All of us need to understand people, know what they may be expected to do and how to induce them to do certain things, and each of us should understand himself, know how to eliminate ways of behaving that

limit his scope of activities and how to build up other ways that conduce to a richer and happier life.

Much information bearing on these problems has been obtained by men in the past and preserved for our use. The physician today has the accumulated experience of his predecessors and contemporaries. He need not derive his knowledge of disease from direct experience, from first-hand observation. But there is still much to be learned, many problems which await solution, not only in medicine but in every branch of science. Further data must be gathered. The process of collecting and organizing such data, whether in the laboratory or elsewhere, is what we call scientific activity or research.

Sometimes it is rather difficult to understand why scientists engage in tasks with so little apparent practical value. The answer lies in the fact that experience has taught that the most practical and far-reaching results are often found in what appears to be the most impractical sort of research. Electricity was first studied from what we might call scientific curiosity, but this seemingly impractical investigation laid the basis for its practical use. In studying the characteristics of atoms, the physicist found a problem which, when investigated, revealed electrons and protons in various numbers and arrangements in the different atoms. Already this finding is beginning to prove practical. The chemist found sugars which were different and yet analyzed into molecules having six carbon, twelve hydrogen, and six oxygen atoms. The question arose as to the source of the differences. Investigation revealed different arrangements of the atoms within the molecules, and when other substances were studied with a view to finding the arrangements of their atoms, it became possible to produce synthetically compounds which previously could be obtained only from living things. Often a psychologist in attempting to find how man learns turns to a study of animals. In the course of his experiments he finds some idiosyncrasy of the animal which arouses his interest and leads him into an investigation without obvious

practical import. Later the bearing of his impractical studies upon practical problems becomes apparent. Nearly all the rules for efficiency in memorizing were suggested from incidental data collected in connection with investigations of the discriminative ability of animals. One practical achievement after another may be accredited to "pure" science, and yet the true scientist often forgets or never considers the practical value of his studies. He wants to contribute to the understanding of things, and if he does this, he is content, whether his findings may prove to have immediate practical consequences or not. This spirit of research is common to all scientists, whatever the field in which they are carrying on their work.

In addition to a common attitude, we find in all branches uniformity in general method. Through the long years of attempting to solve their problems, scientists have come to adopt definite forms of procedure. There are rules that must be followed if progress is to be made, pitfalls that must be avoided. Whatever the branch in which one is interested, one does well to survey the sorts of activities by which the other branches make progress. Those who are interested in psychology will save themselves much valueless labor if they first become familiar with the experiences of the other branches, will gain much by trying to obtain a conception of the way in which scientists in general work. Let us, then, before taking up the special problems of psychology survey the sorts of activities in which scientists are engaged in their attempt to understand the universe. This work may be roughly divided into two sorts: first, the collection of data, and secondly, its organization.

COLLECTION OF DATA

The scientist follows no mysterious method in obtaining his data, which are only the records of verified observations. Since all of us make observations, we can from our own experience appreciate the manner in which the scientist secures his information. In most cases what we perceive receives only our casual

attention. We notice many things with a passing interest. It may be the antics of a baby, the gesticulation of a soap-box orator, the operation of machinery, the erection of a building, the blossoming of plants, or any one of the millions of things going on about us. On the other hand, some object or happening may hold more than this passing interest. Possibly a pet displays unusual behavior. We observe it closely and thus become students of animal behavior. Or perhaps it is a Galileo who notes the pendular motion of a hanging light, a Newton who becomes curious about the falling apple, a Watt who observes with special interest the rising of the tea-kettle lid, or a Franklin who wonders about the lightning flash, and each becomes a student of the observed phenomenon.

After a person has observed some phenomenon that arouses his interest, he does not study it in a haphazard way. Rather he begins to plan, to meditate regarding what sort of investigation is most likely to throw light upon the problem. What he plans, however, is only further observation of the object in its natural setting and a manipulation of it and its environment in such a way that more of its behavior will be displayed. When he has gathered a certain amount of data, an explanation of the phenomenon may occur to him, but this he will consider tentative. Such tentative explanations occurring in the course of investigation are known as hypotheses. If further study confirms an hypothesis, it becomes a theory. When a wide range of investigations substantiates a theory so that it becomes generally accepted, it is known as a law. Let us in this section outline in greater detail the scientist's procedure in making his observations, and in the next we will note how he organizes his data.

A. Field Observation.

The thing a scientist undertakes to study is found somewhere in its natural setting. He may make some observations under these conditions. The chief difference between the field observation of the scientist and casual observation is that the trained

investigator notes with greater completeness what anyone might perceive if he were to observe closely. The scientist's interest, as we have pointed out, is not a passing one. He intends to make a thorough study. Merely to note that a thing happens once is not enough. He waits to see if it occurs again, how often, and under what conditions. He takes notes during the period of observation, for he has found that he cannot rely too much upon his memory. He has learned, also, to guard against biases or, stated positively, to take a scientific attitude. He will make no progress if he refuses to take into account things he would prefer not to find. Many popular and unscientific conclusions and superstitions have resulted from noticing that two things happen together a few times and not observing or refusing to note that they frequently fail to occur in conjunction.

Yet with all the care that might be exercised, the scientist could not proceed far with field observation alone. He needs the aid of refined instruments, needs to isolate the thing he is studying, to observe it under a multitude of conditions which would never, or at least seldom, occur in its natural setting. To do this he takes his problem into the laboratory and sets out on a program of experimentation.

Although many valuable observations of human behavior have been made by persons who have never been in a psychological laboratory, the laboratory is as essential to psychology as to other branches of science. The factors which influence man's actions are so numerous and his everyday conduct is so complex that the effect of a particular factor and the cause of a particular act cannot be accurately determined by observations of the subject in his natural setting. If, for example, one wishes to discover the effects of poor ventilation upon study and the requirements for good working conditions, he must study the effects of different conditions upon some measurable activity such as solution of arithmetical problems and he must determine separately the effects of temperature, of amount of oxygen, of amount of carbon dioxide, of amount of other substances

liberated from the body, and of humidity. To make these studies a laboratory is required.¹

B. Experimentation.

1. *The use of instruments.* Many of the instruments available in the laboratories are to be regarded as direct supplements of the observer's sense organs. Telescopes and microscopes are obviously direct supplements of the eye, which is in itself a sort of miniature telescope, and audio-amplification apparatus is a direct supplement of the ear. Even the instruments of measurement may be regarded in this way. Instead of estimating distance, volume, weight, and time with the unaided sense organs, he measures them with extreme accuracy. The scientist speaks of millimicrons which are one twenty-five millionth of an inch. He measures to a thousandth of a second or less and weighs to small fractions of a gram. Yet with his instruments he comes to a limit beyond which he cannot directly observe. He cannot with the ultramicroscope see atoms, nor can he put them on his scales to weigh them, but he talks about their size and weight with a great deal of confidence. He has other instruments and techniques by which he can make these observations indirectly.

These indirect methods may be illustrated by the manner in which the age of trees is determined. It is quite simple to count the number of rings and thus ascertain the age. But this derivation depends upon knowing from other observations that a ring is produced each year, knowing that the number of rings and the years of life are correlated. Many indirect methods employed by scientists are almost as simple in their use, but for their derivation and validation they depend upon a great number of observations and complex calculations. For example, the degree of acidity of solutions may be readily established by the use of a color indicator. The solution takes on a particular color depending upon the amount of acidity. This color indicates

¹ See Thorndike, E. L., McCall, W. A., and Chapman, J. C., *Ventilation in Relation to Mental Work*. Teachers' College publications, Columbia University.

directly to the eye the acidity, but obviously only if it is known from other observations that a given color means or is correlated with a particular degree of acidness. The derivation of this relationship requires a familiarity with much of the findings of chemistry.

The physician observes in an indirect way the internal organs of his patient. The X-rays which he uses will pass through things that are opaque to ordinary light. Yet even to these rays certain things are opaque and will, therefore, cast shadows. The eye is not capable of seeing these shadows which must be cast upon ground glass or upon a special camera plate. From the developed picture or from the ground glass he sees what he could never discern with any amount of direct sensory supplementation. By the use of X-rays scientists have been enabled to see the arrangement of atoms in crystals and to build up models of the invisible structure of things. In such cases something not directly observable is inferred from things that are, yet the inference itself rests upon observations that establish correlation of the visible and the invisible.

The psychologist has never seen a nervous impulse nor the workings of the brain, but he and other scientists with the aid of their instruments and techniques have gained considerable insight into the nature of nervous impulses and of activities which take place in the brain. With the aid of a string galvanometer they have found that there is a wave of negativity with the passing of a nervous impulse and by means of a biometer that carbon dioxide is released more rapidly. What goes on within us they have discovered with marked but with still incomplete success. The truth of this will be more fully revealed as we develop our study of man and his behavior.

2. *Isolation and control.* In addition to the use of special instruments for improving direct and indirect observation, experimentation involves the isolation of the thing to be studied and control of its environment in order that observations may be made under a multitude of conditions. In the natural setting substances frequently exist intermixed with or

in such proximity to others that it is impossible to be certain that one is observing a substance alone rather than a combination. Thus the chemist is careful to use pure chemicals, the biologist to make certain that he has a pure stock, the physicist to separate light into its component rays. Many of the most baffling problems have developed from the fact that the scientist thought he was studying one thing when, in fact, as revealed by later discovery, he was dealing with more than one thing.

After purification or isolation has been attained, there is also the advantage of being able to study the object's behavior in a known environment. The chemist must, in studying the reaction of one substance to others, be sure that the others are pure as well as the one which is the object of study. The physicist, when determining the speed of falling objects, must know through what density of air the object is falling. The student of animal behavior, in observing the reactions to various colors, must make sure there are no other factors in the environment which may be influencing the reaction made.

Failure to take into account and control other factors has led many to believe that dogs and other mammals below the primates are capable of distinguishing colors, while carefully controlled experiments show that they are color-blind.² Failure to attach importance to visual and auditory cues has led many to believe that dogs and horses can perform complicated arithmetical calculations and answer questions, while careful study reveals that the animal is guided in his performance by cues provided intentionally or involuntarily by his trainer.³ Many human performances which are popularly supposed to involve mental telepathy have been shown to be based upon the detection by the performer of visual and auditory clues.⁴ For

² See Washburn, M. F., *The Animal Mind*, 3d edition, pages 155-157.

³ See Watson, J. B., *Behavior, An Introduction to Comparative Psychology*, pages 299-316; also an article in the *Literary Digest*, Nov. 17, 1928, "Do 'Thinking' Pets Really Think?"

⁴ See Jastrow, J., *Fact and Fable in Psychology*; Coover, J. E., *Experiments in Psychical Research*; and Houdini, H., *A Magician Among the Spirits*.

example, almost anyone can go to an object on which a group of people is concentrating and can do this even when blindfolded. The members of the group make changes in the rate and depth of their breathing and in the amount of noise incidental to shifts of their positions. These auditory stimuli serve to indicate whether the performer is going in the right or wrong direction. The scientist knows the pitfalls of lack of controlled conditions and makes vigorous effort to discover and regulate all factors which may be influencing his results. The psychologist often uses dark and sound-proof rooms in his investigations and frequently arranges his experiment so that he may make his observations in a room adjoining the one in which the subject is placed.

Often there are two or more inseparable environmental factors that determine the form of behavior. The solubility of a substance depends not only upon the nature of the solution in which it is placed but also upon the temperature of that solution. We cannot stimulate an animal with color without also stimulating it with a light intensity. A color-blind individual might react differently to two colors, making the discrimination on the basis of intensity differences.⁵ These factors which influence the behavior under consideration are called variables, and it is necessary that the investigator control or know all variables or that he make sure, through repetition or otherwise, that those which are uncontrollable balance out. Each branch of science has devised special techniques for controlling variables throughout the investigation of any specific problem.

Theoretically a thing would never be completely studied until its characteristics and behavior had been observed in every conceivable environment. Practically it is found that data on things similar to the one under observation will make it unnecessary to try out all combinations. Chemists from the incompleteness of their periodic table had been convinced that

⁵ See Washburn, M. F., *The Animal Mind*, 3d edition, paragraphs 40-42, for a discussion of the problems of investigating color vision.

some elements were still undiscovered, and that if these should be found, they would have certain characteristics. This proved to be the case. Furthermore, to make, at least at present, such theoretically complete studies would be carrying the idea of scientific completeness absurdly far. After all, only sufficient completeness to answer certain problems is desired. It may, indeed, be better to repeat some conditions several times and be sure of these relationships than to try to establish all.

3. *Repetition.* As already hinted, the scientist is not content with a single observation. He has learned that he is an imperfect observer, that in spite of his best efforts he will fail to make complete and accurate observations, that he cannot control all variables which influence his results. Because of these limitations he must repeat his observations and have them confirmed by someone else. In the early days of astronomy before these difficulties were recognized, a youthful astronomer lost his position because his reports of the instant at which stars crossed given points repeatedly differed from those of his superior. Later it was found that even the trained astronomers differed slightly from each other, and still later that when one individual attempted to report repeatedly the exact instant of any signal, his reports would show inconsistencies, so that little reliability could be attached to any one report. Astronomy has largely avoided these subjective variables by the use of instrumental recording, but even instruments are not infallible, and furthermore external variables cannot always be controlled. Repetition is the most effectual manner of taking into account both subjective and objective variables and is effective because sometimes the variables combine to produce deviations in one direction and sometimes in the other. For example, in attempting to determine the relation between volume and pressure, it is almost impossible to keep the temperature absolutely constant, to change the volume by an exact amount, and to measure the pressure with perfect accuracy. But in making measurements of the pressure of a given volume, the temperature will sometimes be slightly higher than was intended and sometimes a

trifle lower so that this variation tends to balance out in a number of observations. It is for these reasons that a thing is not considered to have been scientifically observed until several scientists have each observed it several times.

In psychology it is especially necessary to repeat observations. No person is exactly the same structure at one moment as at another, and the activity under consideration is never the only activity taking place at the moment. Each time a person enters a psychological laboratory to act as subject in an experiment, he is in a definite state of health, he comes from other tasks of a definite nature, and stimulations of various sorts have been acting upon him recently. These recent stimulations will still be exerting their influence, causing him to worry, to be elated, or to be occupied with the formulation of plans or the recall of past events. Furthermore, he approaches the experiment with preconceived notions of what a psychological laboratory is and of what its purpose may be. These factors influence his performance to a greater or less extent, and since their influence cannot be eliminated, it is necessary to repeat observations on the assumption that the influence of each factor is cancelled in the course of the repetitions. Sometimes health will be above average, sometimes below; sometimes worry will be greater than usual, sometimes less. Even in a task as simple as responding to a signal with the greatest possible speed, the subject's reaction time is influenced by the intensity of the stimulus, by external distractions, by muscular tenseness, by fatigue, and by other factors. The only manner of obtaining an accurate measure of a subject's reaction time is to ascertain the speed of reaction several times on different occasions.

4. *Recapitulation.* Scientific observation is set off from casual observation by its completeness and exactness. The latter is obtained by the use of refined measuring instruments, by repetition, and by recording the data before any parts have had time to slip from memory. The former is secured by using instruments which extend the range of our sense organs and by systematically placing the thing studied in various

environments. The scientist must be patient and persistent in order that he may be complete and exact. If he finds himself limited by lack of instruments, he must set about to devise them, and it is obvious that much credit for the advancement of science is due those who devise these instruments.

C. The Things Observed.

Thus far we have been considering chiefly how the scientist goes about his task of observing. We have been assuming that there are things to be observed and that they are real and objective. If we examine a great number of observations, we find that the things described may be divided into two classes, objects and occurrences, or as the physicist would say, bits of matter and forms of energy, or in biological terms, structures and behaviors. From this fact we may decide that the universe is made up of matter and energy. The nouns of our language for the most part designate bits of matter or objects, and the verbs in general express energy manifestations or occurrences.

Observations, however, may deal with relationships as well as with things: (1) An object may be observed in relation to an occurrence, as observing that the telephone rings. (2) An object may be noted in a particular spatial relationship to another object. For example, it may be noted that a chair is near a table. Particularly may the component parts of an object be considered in their spatial relationships, as for example, that the head is on the shoulders. (3) An occurrence may be observed in a temporal relationship with another occurrence. One may note, for instance, that a telephone rings and that someone answers immediately. In the first of these, a combined spatial-temporal relationship is observed, in the second spatial relationships, and in the third temporal relationships. And so it may be said that things exist in time and space.

In what strict sense objects and occurrences, space and time are real and objective is primarily a philosophical question. The scientist speaks of them as if real and objective. When

scientists find that they make progress by speaking of things in this way, they continue to do so, undisturbed by the question of just what is implied by saying, "as if." After all, one of the prime requisites of scientific progress is, it seems obvious, a rigidly defined terminology, *i.e.* one that will release the same sort of activity in all. When we ask for bread, we are not concerned with whether it is real, but with obtaining *it* rather than the proverbial stone.

Even the observation of a single object or occurrence implies space and time. An object, as we shall see in more detail later, may be best defined as a relatively stable grouping of the units of matter, and an occurrence as relatively stable temporal grouping of the units of change. One could not observe a telephone unless it had spatial characteristics that are much the same from time to time, nor could he observe the ringing of a telephone unless it had temporal characteristics that do not differ greatly from one time to another. Thus, it is seen that an extensive problem may be raised as to how we are able to make even the simplest observations and as to what the simplest things are. But whatever the solution of these problems, we do make observations, and when we report them to others, they understand what we have observed.

Omitting, then, a discussion of these questions, we may summarize by pointing out that observations may, from the standpoint of what is being observed, be grouped into five classes: (1) observation of the structure of an object, *e.g.* the construction of a house and its characteristics; (2) observation of the components of an occurrence, *e.g.* the sound waves involved in the ringing of a bell; (3) observation of occurrences in relation to the objects from which they arise, *e.g.* that it is a blast of dynamite that is heard; (4) observation of the spatial relations of objects, *e.g.* that the windows of a house are six feet apart; (5) observation of the temporal relations of occurrences, *e.g.* that the explosion of the gunpowder is followed by the projection of the bullet.

ORGANIZING DATA

A. Analysis of Structure.

As an object is studied, it is found that it may be resolved into various parts, each having its own characteristics. A house may be analyzed into building materials, each of which is a structure with its own peculiarities. A molecule is found to be made up of atoms with their own characteristics. Analysis may be continued until all things have been analyzed into the smallest parts known. These are electrons and protons. Not all objects can be thus thoroughly analyzed at present, but it is possible in so many cases that scientists are led to believe that eventually it will be possible in all. In a sense, then, all objects are merely electrons and protons.

If this be true, the question naturally arises as to how objects differ. The answer is suggested in the fact that the above is only a part of the analysis. Two houses may have the same kinds of materials and the same amounts of each and still be different, owing to the arrangement of the elemental parts. Two molecules may be made up of the same sorts of atoms and the same number of each sort and still be unlike. There are many sugars that have six carbon, twelve hydrogen, and six oxygen atoms, the difference lying in the manner in which these atoms are arranged. Objects, as we know them, are not merely aggregates of parts; they are these parts in a specific arrangement. Water is not merely hydrogen plus oxygen, but hydrogen and oxygen in a particular configuration. When a new arrangement of electrons and protons or of parts of any complexity is achieved, something has in a sense been created. A requirement of fundamental importance in understanding the universe is to have a knowledge of how new arrangements of electrons and protons occur. We shall touch upon this shortly. At present we are concerned with the fact that scientists do analyze the arrangements that have been achieved and that they bring together the data from many sources in presenting the existing status of analysis for a given object.

The practical value of these analyses may be seen from the following. Only recently have chemists discovered the atomic arrangement of the molecules of many substances, particularly organic materials. They are now able to produce in the laboratory many of these compounds, perfumes, flavoring extracts, medicines, that were previously obtainable only from living things. Many analyses of relatively simple things remain to be completed, and, as we have already stated, our ability to use those things to the fullest extent awaits such analyses.

B. Analysis of Behavior.

To describe behavior is to say how an object moves, how its parts move, or how they change their spatial relations. Many of the words which we apply to activity are designations of groups of movements. The activity of a bell which is described by saying that it rings is composed of vibratory movements of the metal at several frequencies and in various amplitudes. The activity of man designated by saying that he walks is a complex of movements. Movements which regularly appear together are commonly referred to as forms of behavior and are capable of analysis just as an object is capable of being resolved into its component parts. This analysis involves a description of both the nature and grouping of the component movements, just as the analysis of an object involves a description of both the nature and arrangement of its parts. Walking is not merely flexing the legs, moving them forward, and straightening them; it is these movements (and others) in a definite temporal pattern.

As we examine more carefully what is meant by a simple movement, we find that we are in reality describing the movements of simpler parts. Movement itself cannot be described but only the direction and rate of objects in motion. It may be in a straight line, *i.e.* linear, or it may be circular, elliptical, sinoidal, vibratory, and it may be fast or slow, but it is always a movement of something. We never say, "I see movement," as we say, "I see an object," but rather, "I see an object moving

in a certain way," or "I see a certain movement of an object." In complex objects there may be a number of movements of the parts as well as the motion of the whole, and over a period of time the movement of the parts may change in direction and rate in a characteristic way. These complex patterns and sequences to which we have assigned names are the forms or ways of behaving ordinarily used in description. A piano string emits a characteristic note, its movements being a complex of vibrations of the whole length, of half the length, of a third the length, etc. It is, then, more accurate to say that forms of behavior analyze into movements of the constituent parts of objects rather than into simpler movements.

C. The Behavior Characteristics of an Object.

To describe the total behavior of a substance, an object, or an organism is a task of some length and often beyond the ability of any one scientist. One chemist may determine the solubility of a substance, another its freezing and boiling points, a third its reactivity to some environments, still another its activity in other environments. Likewise in biology or any other branch, many men may study the behavior of the same object, and all these studies are collected to give a picture of its total behavior. A textbook in psychology is one writer's attempt to present a picture of man's behavior as best he is able to draw it in the light of all studies.

D. Classification.

As data with reference to structure and behavior accumulate, a similarity in the descriptions of some objects is found. These objects are grouped together and given a class name. The best grouping may necessitate sub-classes of various orders, as in zoölogy where animals are classified with respect to orders, families, phyla, species, and genera, or as in chemistry where the elements are grouped in the familiar periodic table. This grouping is advantageous in two ways: it enables the scientist to impart his information with greater ease, and it shows him at a glance what he may expect of things with which he has

had little experience. In fact, as we have already noted, it has done more than this in the case of the periodic table by leading him to discover new elements.

E. Generalization.

Just as the scientist in organizing his data groups objects, so he brings together various instances of behavior on the basis of similarity in form and antecedents. Unsupported objects of all sorts, apples, feathers, leaves, fall to the ground. If the friction of the air is removed by placing the objects in a vacuum, it is found that they all fall at the same accelerated rate. A general statement may now be made to fit these cases. It involves a specification of the conditions under which the behavior takes place and the description of the sort of behavior. Such statements are known as laws, and all may be formulated: when this is found, that also is found. When an unsupported object in a vacuum is observed, it is found to be going toward the earth with an acceleration of 32 feet per second, or when a nervous impulse is delivered into a muscle, the muscle contracts.

F. Explanation.

In a sense science never explains. It merely describes and organizes its descriptions. Yet the organized description leads us to say that we "understand," that for us the phenomenon is "explained." What we mean is that we know the conditions under which the phenomenon is exhibited, know when to expect it to take place. The law of gravity tells us that we may expect unsupported objects to fall. We may say that the object's relationship to the earth accounts for or causes its falling, but quite obviously all that is being said is that objects do fall when they are near the earth.

If a layman is asked why objects fall, he will in all probability say that the force of gravity is the cause. Scientifically defined, force is mass times acceleration. It is obviously absurd to say that an object falls because it has acceleration, that is, because it is falling. Gravity is the going-toward-the-earth behavior

of masses. To say that an object falls because of gravity is to say that it falls because objects fall. This is obviously redundancy or tautology and not explanation. Such statements are similar to saying that we can't sleep because we have insomnia, that rubber stretches because it is elastic, that steel is hard to pull apart because it has high tensile strength, that a car is capable of great speed because it is a fast car, that a student is good in his studies because he is intelligent, that he remembers well because he has a good memory. Whatever the reason for making such statements, science cannot employ them. Scientific explanations, in so far as they may be termed explanations, are merely organized descriptions, statements of observed relations.

In many cases, before the scientist can give an explanation in the above sense, he must make an analysis of the structure and of the conditions present to show that they are covered by some law. When an engineer undertakes to explain why a car is capable of great speed, he shows by analyzing its construction that certain features are present. He then points out that it has been observed that when these features are present, certain speed may be attained. When the chemist formulates his explanation of the union of hydrogen and oxygen to form water, he first shows that hydrogen can be made to lose an electron and become positive electrically and that oxygen can be made to take on two electrons and become negative, the oxygen being twice as negative as the hydrogen is positive. He next points out that particles of unlike sign go together and that it requires the combination of two hydrogens with one oxygen before the oxygen ceases to be negative. This type of organization of data for explanation is seen to be a step beyond the types previously discussed. In explaining observed phenomena, the scientist utilizes his information with reference both to the nature of construction and to characteristics of behavior as formulated in laws. Scientifically man's action is to be explained in terms of his construction, its physiological characteristics, and the environmental conditions present. Science will

reach its culmination when each thing observed can be explained in this sense. Great inroads into the secrets of nature have been and are being made, but one need not follow far to be impressed by the fact that for every problem solved two new ones are to be found. As science progresses, it develops a general conception of the various phenomena and continuously revises this conception.

From the foregoing it would seem clear that science uses the terms cause and effect in a restricted sense. When one happening is repeatedly and invariably observed to be followed by another, it is said to cause the other. But this happening that causes has in its turn been caused and the one that caused it has also been caused so that theoretically there is no beginning to cause. Likewise there is no end to effect, for the effect of one thing becomes in its turn cause for something that follows. Also theoretically there are no spatial limits to cause and effect, because, as we shall see presently, the smallest disturbance at any point in space is regarded as affecting everything else in the universe. The temporally distant antecedents and the spatially distant effects may in the practical work of the scientist be neglected, for, as we have seen, to understand a thing is to be able to predict what it will do under various conditions and to be able through control of the conditions to make it do what is expected of it. This conception of cause, the employment of the term explanation in this sense, makes absurd such statements as, "Science knows not one thing about the real nature of gravity, capillarity, electricity, etc." It is the unscientific thinker who takes over the descriptive terms of science and makes of them names for mysterious forces. These names are for the scientist merely terms that describe the way objects behave under given conditions. Capillarity describes the fact that sap goes up the tree, that liquids rise in small tubes, and was never intended as the name for some mysterious unknowable "something" that "causes" these phenomena. The cause of the sap's rising is the nature of the sap and the small tubes in the trees, nothing more, and this may be said to be the cause

only because it has been observed that sap does rise in these tubes.

The same line of reasoning leads to the conclusion that intelligence is a term used to describe the relative performance level of people or animals. It is not a mysterious force which causes one person to be highly efficient and another markedly deficient. Likewise, honesty is a term used to describe how people act in concrete situations. It is not a mysterious force which causes a person to act in a specific way. The reason that he acts as he does is the nature of his nervous system as determined by training, and this can be said to be the reason only because it has been observed that one sort of training results in honesty in action and another in dishonesty.

We may now expand our tentative definition of scientific activities given in the opening sentence by stating that they are the activities of man in describing, classifying, relating, and explaining the phenomena of his environment. From the consideration of these activities we may turn to the question of the general conception of the universe that has been reached.

THE CONCEPTION OF THE UNIVERSE

We have pointed out that as science studies various objects it finds that it can analyze them into parts and in turn analyze these components into still smaller parts. A table is made up of legs and top. Each of these is composed of definite materials—wood, iron, marble. These materials, when subjected to chemical analysis, are revealed to be aggregates of molecules of definite sorts. Molecules are shown to be made up of atoms combined in definite proportions. Atoms, in turn, are combinations of electrons and protons. It is possible to analyze so many objects into electrons and protons that scientists are led to believe that, as their study progresses, all objects will be thus analyzable. The universe they then conceive as an aggregate of electrons and protons.

Electrically protons are positive and electrons negative, and as a result the variety of arrangements giving objects as we

know them is evolved. If the universe were made up of all like-signed particles, they would retreat as far as possible from each other. (Like-signed particles have repeatedly been observed to go away from each other.) In this case each division of space would be like every other; there would be no objects. If one had a hundred balls to place on the floor of a room and had to put each a maximum distance from others there would be only one possible arrangement and the grouping in one corner would be like that in any other corner. A variety of patterns would be impossible. Again, if the universe were made up of particles all different in sign, they would go as close together as possible; there would be one mass of material and any part of the mass would be like any other. If one had to place the one hundred balls as close together as possible, only one arrangement could be made, and one quadrant would be like any other. The universe, however, is made up of both like-signed and unlike-signed particles. In consequence, the particles go to neither extreme pictured above; they tend to go both toward and away from each other. Because of both similarity and dissimilarity of sign, objects of great variety are evolved. If one could put some of the hundred balls close together and some far from others, a great number of different arrangements would be possible.

The analogy of electron-proton arrangement and the arrangement of balls does not hold in two respects. The balls are arranged on a surface, while electrons and protons are grouped in three dimensions; and the balls are stationary, while physicists conceive that electrons and protons are in constant motion. An electron and proton approach each other to form a hydrogen atom, the simplest of all electron-proton groupings. Both keep moving, the electron whirling about the proton much as the moon whirls about the earth. All atoms are neutral electrically. This neutrality gives them a degree of stability. The electrons protect the protons against invasions, and the protons protect the electrons. The stability is, however, not absolute. As the atoms move about or as other groupings move about them, the

fast-moving electrons fly off and join another group. Atoms or groups of atoms which have lost their neutrality are called ions by the chemist. For example, the hydrogen atom which has lost its electron is the hydrogen ion with one unit of positive charge, and an oxygen atom which has taken to itself two extra electrons is the oxygen ion with two units of negative charge. The hydrogen and oxygen ions unite to form water molecules, and again a relatively stable neutral system is formed. But it, too, may be disrupted.

Evolution and change are fundamental to the nature of the universe. New arrangements of electrons and protons are being continuously developed, and each new arrangement introduces new forms of behavior. Each object is old in that it is composed of old electrons and protons, but each is new in that it is a new arrangement. The new arrangements are evolved when new relationships between existing substances and objects are developed. As the chemist and physicist learn more about the universe, they find more and more of the relationships required for the development of definite substances. Only a few years ago they did not know the conditions required for producing many substances which plants have been producing for ages, while today they are acquainted with many of these conditions and can produce flavoring extracts, perfumes, sugars, medicinal extracts in their laboratories. Their discovery and isolation of catalysts have been important factors in making this step. A catalyst is a substance which by its presence accelerates and aids reaction between other substances without being itself destroyed. A familiar catalyst is the green substance of leaves, the chlorophyl. In its presence carbon dioxide and water unite to form starches and sugars which are the chief building materials of plants. In the presence of other catalysts sugars and other food substances are synthesized into more complex compounds, particularly the proteins which are the chief building materials for animals. Out of new relationships of existing structures there are created new arrangements of electrons and protons to form new substances which in turn contribute to

the forming of still newer substances; there is continuous evolution and change.

THE CONCEPTION OF ENERGY

We have said that as a particular electron-proton arrangement is achieved, it becomes fairly free from other electrons and protons. This freedom, however, is never complete. It is great enough to enable the system to continue for a time, some systems continuing much longer than others. This ability to continue we term the stability of the system. Even during this period the system is now in one relation to the rest of the universe and now in another. As the relationship varies, the structure makes certain changes, and we call these its behavior. Commonly we consider that energy is expended in behavior. What is this energy, and what is its source?

When we look for the origin of the word energy, we find that it was coined to express one-half the product of mass and velocity squared. This product is important as a measure of the amount of destruction done by an object. In the case of a falling stone its energy is not conceived to be the cause of the falling, but rather only one-half of the mass of the stone times the square of its velocity in falling. The energy of the stone may, however, be considered to cause destruction in the object which it hits, for it has been observed that when an object strikes it *does* destruction proportional to its force. In this sense the force of destruction resides in the falling object and is a form of kinetic energy. It is seen, then, that energy is merely movement of particles. In some cases we cannot directly see the movement as *e.g.* the movement of electrons in a copper wire, or the movement of the air particles as they produce sounds.

As to the source of energy or movement, scientists say no more than that in particular relationships of objects particular movements will occur. Energy is always a movement of something in relation to something else. It is permissible to say that energy is derived from relationships. One electron-proton

grouping in a particular environment of other electron-proton arrangements moves in a certain way, and so it may be said that all energy is essentially the fundamental electron-proton motions. If there is movement of any object in a given direction and at a given rate, there must have been simultaneously change in the direction and rate of movement in other objects. This reasoning, as well as many measurements that have been made, has led scientists to conclude that energy as well as matter can be neither created nor destroyed. Both, however, can be changed in form. The universe, then, is most aptly conceived as a continuum of movements, a continuous shift in electron-proton relationships, in which our division of time into seconds and distances into inches does not exist. Such divisions are man-made and arbitrary, but distinctly useful or, as sometimes aptly termed, are convenient fictions.

QUESTIONS AND EXERCISES

1. Outline the chapter, and then from the outline headings formulate a set of questions as suggested in the preface.
 2. Elaborate the statement, "Many of the instruments available in laboratories are to be regarded as direct supplements to the observer's sense organs."
 3. Does science deal merely with facts or is it interested in interpreting facts? What is a fact? Illustrate from the field of physics, chemistry, botany, zoölogy, and astronomy.
 4. Try to find several instances in which "impractical investigations have led to practical results."
 5. Write out your conception of cause and effect or stimulus and response.
 6. Write answers to one or more of the following questions:
 - a. Why does a sewing machine sew?
 - b. Why does a percolator percolate?
 - c. Why does gunpowder explode?
 - d. Why does an electric motor revolve?
 - e. Why can one lift a greater weight with a lever than without?
 - f. Why does a gear driven by one with twice the diameter revolve twice as often as the driving gear?
 - g. Why does a camera take a picture?
- Compare your answers with what was said in the text with reference to the nature of scientific explanations.

7. Much pseudo-psychological material is placed before the public. Some of this appears in popular magazines and Sunday supplements and some is advertised as insuring memory improvement, salary increase, strong and impelling personality, general success. Examine two articles and one advertisement and note violations of scientific principles.

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CHAPTER 2

PSYCHOLOGY

You have started to read this book in the hope of coming to a better understanding of yourself and others. You wish to learn how fears arise and how they may be dispelled, to discover what makes a person timid and self-conscious, how these traits may be overcome, to find how we remember, imagine, reason, evaluate, and how we may become more proficient in these activities, to know why one person is gracious, generous, original, while another is deficient in these characteristics. In reading the first chapter, you have wondered at times what it has to do with the problems of human conduct. The answer is that there are rules to be followed and that there is a definite point of view to be taken if one is to meet with success in understanding problems of behavior, whether they arise in connection with the behavior of inanimate things or of human beings. Chapter 1 dealt with these rules as revealed by an examination of the methods and attitude of science in general. We are now ready to consider their application in psychology.

Since all normal persons are continually confronted by problems of conduct, each of us has developed, either from being taught or from his own thinking, some theory to account for human action. These theories have for the most part been evolved without thought as to their scientific validity, and as a result many students approach psychology with preconceived notions which conflict with scientific principles. Of course popular theories of today are not so crude as those of primitive man. We do not, like him, use witchcraft to drive out an evil spirit which has supposedly taken possession of us, nor do we believe that kindness to eagles which have ability to see at great distances will improve the keenness of our vision. Yet there are current

many popular beliefs and explanations which are almost as far from meeting the demands of science.

As an example of the readiness with which we put forth theories that are not valid, let us describe a mythical beast of the sort devised by Holt in *The Freudian Wish*. (Figure 1.) The beast has two eyes, one on either side, and a pair of responding organs—legs, wings, or fins—bilaterally placed. The eye on the right is connected with the responding organ on the left by means of a nerve, and a second nerve unites the eye on the left and the effector on the right. This beast, let us say, always goes toward a light. Without Chapter 1 or its equivalent as a background you would be tempted to explain the act by saying that he is curious about the light, likes it, is attracted to it, approaches it because of instinct or possibly because of intelligence. After reading the discussion of the nature of scientific explanation, the tautology is obvious. To say that he goes to the light because of curiosity is to say that he goes to the light because he goes to it. Curiosity is a way of behaving, not a non-physical force that directs behavior. We are as far from explaining the behavior of the mythical beast after referring it to curiosity as we were at the outset. The chemist might with equal accuracy speak of hydrogen atoms going to oxygen atoms because of curiosity, fondness, instinct, and the physicist speak of a rain-drop falling because of a fondness for the earth or a curiosity to see what will happen in its fall.



FIG. 1.—The mythical beast. Explanation in text.

Pseudo-explanations of this sort are involved in each of the following statements. A recites a poem which he has not read for some time because he remembers it or because he has a good memory. B can study in the presence of distractions

because he has a strong power of concentration. C receives good grades because he is intelligent. D can put his hand in hot water because he has a strong will power. E can decide which college he shall attend because he has the power of choice. F is antagonistic to G because he hates him. Because H is honest, he returned the money which he found. J, because he is cruel, beats his horse. M does not play golf on Sunday because he has a strong Puritan conscience. Whenever such terms as memory, will power, and honesty are used in an explanatory sense, a scientific explanation is not being given, but rather a tautological statement is being made. The frequency of the use of these terms as explanations is evidence of the statement that there are many popular notions which do not meet the demands of science.

THE NATURE OF PSYCHOLOGICAL EXPLANATION

What, now, is the explanation of the mythical beast's approach to the light? In Chapter 1 we found that scientific explanations are given in terms of the nature of construction and known laws. We have indicated the chief features of the construction of our beast, and a statement of the following laws will complete the explanation. Ether waves set up action in eyes, this is followed by activity in nerves, and nervous impulses trip off action in responding organs. The amount of action in these parts is a function of the intensity of ether waves, the intensity of ether waves diminishes as the square of the distance of their source, and their effectiveness decreases with a departure from striking at right angles. With the light to the left as illustrated the left eye is more affected, and action in the right effector is more vigorous. The animal, being free to turn, is turned to the left as is a boat propelled more strongly on the right side. As this turning takes place, the intensity of light to the two eyes is equalized, and the animal proceeds directly toward it.¹

¹ See Loeb, J., *Forced Movements, Tropisms, and Animal Conduct*, for a study of animals which exhibit behavior similar to that imputed to our mythical beast.

Our discussion of the mythical beast and the presentation of the nature of scientific explanation given in the preceding chapter have suggested the requirements in attempting to understand human acts—a familiarity with the structure of man's sensori-neural-muscular system and a knowledge of the laws which pertain to its functioning. Although Chapter 1 dealt but little with problems of psychology, it nevertheless was valuable in giving us a conception of how psychology should proceed if it hopes to explain human behavior. Let us next see if there are some general concepts or principles which other branches of science have developed in attempting to explain the behavior of the objects in which they are interested. These may serve as guides to the sort of data we should try to collect and organize in order to understand the behavior of the object which we study.

A. Scientific Principles of Behavior.

1. *Every movement is preceded or accompanied by another.* This principle is a generalization from countless observations. Inanimate structures have been observed to respond only when there is a change in their relationship with their environment. The ammeter on the dash of an automobile, for example, behaves or moves only when an electrical potential is created across its terminals. Gunpowder explodes when heat is applied. This principle is most commonly called the law of the conservation of energy. It may be stated in any one of several ways. Every movement is preceded or accompanied by another, energy is conserved, changes in the relationship of the structure and its environment elicit or cause its responses, behavior is not self-originated or spontaneous. The principle suggests that psychology may, when it is concerned with an instance of human behavior, take pains to look to the change in the relation between the organism and its environment to discover what was responsible for the act, may do well to seek a physical cause of each act.

2. *The nature of the object's construction determines the environmental conditions to which the structure will be sensitive.* The

characteristic movement of the hand of an ammeter cannot be released by allowing light to shine on its terminals, nor by many other conditions that might be brought to bear upon it. The nature of the ammeter determines which relationships with environment will be followed by behavior. Many observations of this sort have led to the acceptance of the principle that the construction determines which conditions will be effective. This principle suggests that psychologists may do well to direct their attention to a study of human construction to find why we respond only to certain stimuli.

3. *The nature of the object's construction determines the form of response evoked.* The fact that gunpowder *explodes* is determined not by the application of heat but by the nature of the gunpowder. The fact that the hand of an ammeter *swings to the right* is determined not by the presence of an electrical current but by the way the ammeter is constructed. An electrical potential across the terminals of a light bulb gives rise to incandescence, across those of an electric motor to rotary motion, and across those of an electric iron to heat. The form of response in each case is determined by the structure of the reacting object. A change in environment releases action, but the form of action released is a function of the sort of structure that is responding. This principle suggests that psychologists should study human construction with a view to finding why men exhibit characteristic forms of response.

4. *When an object is capable of more than one form of response, the particular response exhibited is a function of the object's construction and the environment acting.* Whether water shall freeze or boil or evaporate or hydrolyze depends upon the conditions under which it is placed. That it is capable of these different actions is due to its construction. Whether man shall fight or run or do any one of the many things of which he is capable depends upon the conditions surrounding him. That he is capable of the many forms of action is due to his construction.

5. *Each structure is the one it is as a result of what its initial structure was and of the environmental influences which have been*

operative since its origin. A piece of crumpled paper in the waste basket is what it is because of what it was when it first became a piece of paper and of what has happened to it since. In being folded and crumpled it became modified. It would not be what it is today if it had not been what it was originally and if it had not been folded and crumpled. Its past lives in its present: it remembers. Again, a diamond is what it is as the result of an antecedent material having been acted upon by a particular environment, and this antecedent substance what it was in consequence of the influence of a special environment upon a further antecedent structure, and so on back through a whole series of antecedent structures. Sometimes we give a structure a new name after it has been modified, as in the case of a diamond after it has originated from carbon deposits, and sometimes we keep the same name and modify it with an adjective, as in the case of a crumpled piece of paper. The point at which we speak of the creation of a structure is an arbitrary matter, for, strictly speaking, each existing structure has been in process of being created since the beginning of time. This principle suggests that each person is the person that he is as a result of what he was yesterday and of what has happened to him since, that he was what he was yesterday because of what he was the day before and of what happened to him in the interim, and so on back to what he initially was at conception, the time we arbitrarily assign as the beginning of his existence.

B. Postulated Principles of Human Behavior.

These suggestions when stated specifically for man would read as follows:

- (1) Any specific instance of human behavior is elicited by certain changes in the individual-environmental relationship.
- (2) The nature of a person's construction determines which individual-environmental relationships will be effective.
- (3) The nature of the person's construction also determines the possible forms of response which may be released.

(4) The particular response exhibited at a given time is a function of the nature of construction and the stimulating agent active.

(5) The person is the structure that he is as a result of the nature of the fertilized ovum from which he originated and the environmental influences under which he has developed.

The question of whether we shall adopt these suggested principles hinges upon our conception of man. If we adopt them it means that we shall regard man as a reacting structure, as a physical object in a world of physical objects. There is much in favor of conceiving him in this manner.

Like other structures he is made up of parts, head, trunk, and limbs, and these are composed of smaller parts, eyes, nose, mouth, etc. These in turn are shown under the microscope to be made up of cells. Cells may by microscopic and chemical analysis be shown to be composed of smaller parts, cell wall, cytoplasm, nucleus, and these of colloids, proteins, etc. However, this cellular analysis is not complete. The constituents of the cell are chemically complex, and the organization of the components is highly baffling. Much progress has been and is being made toward demonstrating the relation of cells to physico-chemical systems, and it seems justifiable to assume that such an analysis will eventually be completed. At present, man is not shown in a thoroughgoing manner to be an electron-proton organization and hence a purely physical structure; yet it seems best to start with the assumption that he is. Unquestionably much valuable information may be gathered from this point of view. Attention is called to the fact that the assumption is not an assertion of truth, but rather a working hypothesis, adopted in the hope of obtaining a better understanding of man's behavior.

Since the individual grows and changes, it would not be correct to say that he is a specific object. Rather he must be conceived to be a series of structures or a continuously changing one, the changes never being great enough from day to day to

warrant the use of a new name for each structure in the series even though during the period from conception to death the changes are considerable. The human individual, it seems, can best be defined as a series of specific structures starting at conception and terminating at death and classified by zoölogy as belonging to the species of *homo sapiens*.

This conception of man and of the causes of his actions is widely divergent from the current view. Popularly the most important feature of man is considered to be his mind, which is accorded this high position because it supposedly interprets the world about him, makes a pattern of stimuli mean a definite object or occurrence, a house, a chair, an explosion, a storm. Presumably it also determines the course of his action, causes him to enter his house, sit upon a chair, cease work when the bell rings. In contrast to this is the view developed in this chapter, the conception that it is his construction which determines the form of his behavior. We should hold that Tommy reinterprets and acts differently toward nut cake after having been sickened by it because of modifications produced in his inner structure, especially in his nervous system, while the popular notion is that the change is due to an impression made upon his mind. On the surface there does not seem to be such a great disparity between the two concepts, but to hold the popular view is to center interest in something non-physical, something that cannot be studied as the physical sciences study the objects of their interest, while our view directs attention toward the discovery of objective facts and principles. We, it must be emphasized, are interested in finding causes of action, in studying what is popularly attributed to the mind, but regard for scientific principles and attitude leads us to ignore the concept of mind and to seek an understanding of behavior through a study of the biological characteristics of man.

Having adopted for the sake of study the assumption that man is a reacting structure, the principles of behavior which we have taken over from the physical sciences become for us postulates, *i.e.* principles which until we find evidence to the contrary

we shall regard as true even though we cannot in a thorough-going way prove that they are true.

C. Corollaries of the Postulated Principles.

In postulated principles (2), (3), and (4) (page 33) construction appears *as a determiner of* behavior, and in principle (5) *as being determined by* the nature of the germ plasm and past environment. This makes it mathematically possible to substitute the phrase "the nature of the person's germ plasm and past environment" for the phrase "the person's construction" in principles (2), (3), and (4). In mathematics it is shown that if 'a' is a function of (varies with or is determined by or determines) 'b' and if 'c' is a function of 'a,' then 'c' is a function of 'b.' If construction (a) determines the effectiveness of stimulation (b) and if the nature of the fertilized ovum and past environment (c) determines construction (a), then the nature of the fertilized ovum and past environment (c) determines the effectiveness of stimulation (b). Each of the three following corollaries is derived in this manner:

Corollary 1. *The nature of the fertilized ovum and past environment determines which individual-environmental relationships will be effective.* This corollary is deduced from principles (2) and (5). It tells us that we may explain why a person responds to one stimulus rather than to another in terms of heredity and environment without reference to structure. If one person sees a book in a window while another sees a mechanical toy, we may seek the explanation of the difference in terms of dissimilarity in the heredities and the environments of the two. We need not seek a difference in construction although we implicitly assume that this difference exists. Neither this corollary nor principle (2) leaves any room for explaining *selection of stimuli* in terms of chance or free choice.

Corollary 2. *The nature of the fertilized ovum and past environment determines the possible forms of response which may be released.* This corollary is deduced from principles (3) and (5). It tells us that the variety of responses of which any person is

capable may be accounted for by his heredity and past environment. We need not refer to construction although again we assume it. The inventions of a genius are to be explained either in terms of heredity and environment or in terms of construction. Neither this corollary nor principle (3) leaves any room for explaining *additions to one's repertoire of acts* in terms of spontaneity or chance.

Corollary 3. *The particular response exhibited at a given time is a function of the nature of the germ plasm, the past environment, and the present stimulating agent.* This corollary is deduced from principles (4) and (5). It tells us that if a particular stimulus is active, the form of response which is evoked may be accounted for in terms of heredity and environment without reference to structure. If Tommy in the presence of nut cake refuses it rather than eats it, we may seek the explanation in his past experience with nut cake. In searching for this explanation we are of course assuming that Tommy's past experience has left its imprint upon his construction. Neither this corollary nor principle (4) leaves any room for explaining *selection of response* in terms of chance or free choice.

D. The Constructional and the Historical Types of Psychological Explanation.

The derivation and statement of these corollaries have served to point out something which might otherwise have escaped us. We need not explain an act in terms of construction to give a perfectly valid scientific explanation: we may equally well explain it in terms of past conditions. Explanation in terms of the history of the structure is the type employed in accounting for many phenomena. If a letter has been folded and thereafter refuses to lie flat, we explain its refusal by reference to its past experience. We account for a photograph by referring to the exposure to which the film was subjected. The lumpiness of salt or sugar we attribute to its exposure to moisture. If a person performs some task well, we hold his previous practice responsible. A historical explanation is valid if it can be shown that the past

conditions used in the explanation are necessary antecedents of the present characteristic of action.

If, however, we are deeply interested in an act, we will seek both the historical and the structural explanations. We will want to know why salt and sugar absorb water, why the exposure of a film leaves a photograph, why an illness creates a distaste for nut cake, why practicing an act increases skill in the act. In answering these questions we are inescapably thrown into a study of construction. The psychologist will want to employ both types of explanation.

THE NATURE OF PSYCHOLOGICAL DESCRIPTION

Having seen the import of a scientific attitude and procedure in dealing with the problem of psychological explanation, let us note the requirements for the description of human behavior. Movement or behavior is conceived by the physicist as having only direction and rate. Movements are differentiated according to the object or part moving. Complex movements are those involving the simultaneous or seriated movements of several parts, and we have developed words to designate the whole complex. If you touch a hot object, your reaction is for most purposes adequately described by saying that you quickly withdraw. This reaction may, of course, be analyzed into the rapid retraction of the hand, stepping backward, jerking the body erect.

In addition to these movements it may be that you cry out. The statement that you cry out does not specify the direction and rate of any of your movements but rather the effect of the activities in your vocal apparatus. This is analogous to describing the behavior of a bell by saying that it rings rather than by specifying the frequency and amplitude of the vibratory movements of the metal. The fact that there is scarcely any other manner of characterizing in a concise and significant way the actual movements involved justifies and makes legitimate the use of this type of description. After all, the observer of behavior is a person, and to describe an action in auditory

terms—sounds—is as satisfactory as to describe it in visual terms—direction and rate of movement. The observer may supplement his sense organs with instruments and thereby secure from an action which is ordinarily detected by the ear a record that is observable by the eye, one in which direction and rate may be discovered. But this does not invalidate descriptions of movements as they are detected through the ear. Auditory description implies a pattern of movements having direction and rate, but it does not specify the direction and rate of the components. In a sense, then, it is an inferential description of movement.

Even when we describe actions in visual terms, we often designate the results of the activities rather than analyze and specify the direction and rate of the component movements. Saying that a person is writing the letter 'd,' moving a chair, driving an automobile is perfectly valid description.

When behavior is described in terms of its effects, there is a danger that the description will be taken for an explanation, that the movements will be thought of as being performed *in order to achieve the effect*. Certainly man and animals not only behave or move, but they accomplish something by their movements. A beaver in building a dam is not merely going through various motions but is accomplishing the building of a dam. A squirrel in storing nuts is not only performing specific acts but is obtaining a winter's food supply. A person in drawing away from a hot stove is not merely flexing his arm but is protecting himself from injury. This fact has led some psychologists to insist that behavior is primarily purposive. Certainly it is indisputable that behavior does serve purposes, achieve results, have effects or consequences. Furthermore, the same effect may be achieved through different sets of activities. The beaver may in different streams build his dam with highly dissimilar movements. But granting all this, it is not permissible to say that the movements are executed in order to achieve an end, in order to accomplish a purpose. Teleology, *i.e.* explanation given in terms of results, is not valid. If explanation is what we

described in the previous chapter, if cause is that which precedes, then the teleological type is unsound, is no explanation at all. Certainly every action of an inanimate object has results as have the actions of living organisms, but the physicist and chemist do not use those results as a part of their explanation. The raindrop strikes the earth by virtue of its falling, but it does not fall in order to strike the earth. The explosion of dynamite does dislodge rocks, but we would not attribute the explosion to the movements of the rocks. To include in the discussion of the behavior of dynamite the fact that it will move rocks may well help to describe its action but does not *explain* it. Likewise, to incorporate into the treatment of human behavior the effects of acts may be helpful in describing them but does not contribute to the discovery of their causes.

We may conclude that there are two sorts of psychological description, the one a direct description of movements, the other an inferential description in terms of effects. Let us call the former bio-physical and the latter bio-social, as suggested by Weiss.² Bio-social description enters into psychology to a greater extent than inferential description enters into physics and chemistry. There are two reasons: (1) Man's behavior is much more complex than are the activities of inanimate things, and the more complex the behavior, the more useful is description in terms of effects. (2) Psychologists are not interested in describing any and all activities displayed by man but are concerned primarily with that behavior which is socially significant, that which enters into the determination of the individual's social status, that which has appreciable consequences in adjustment.

Organismic action is characteristically seriated, and whenever we observe repeatedly that a series of movements is followed by definite consequences, subsequently the observation of any one of the movements leads us to think of the others and of the consequences. We associate the whole group as we con-

² Weiss, A. P., *A Theoretical Basis of Human Behavior*, p. 78 ff.

nect the dinner gong with dinner. If we see a bird with a twig in its mouth, we know that it is building a nest even though we do not see the nest. Obviously, unless we have previously seen birds with twigs in their mouths and had seen a number of twigs deposited to form a nest, or had read about these activities, we should not describe the bird's behavior as a part of the process of nest-building. In the light of previous observation the one bit of behavior becomes not merely an instance of behavior but rather a part of a whole group of acts. The thing that unifies for us the various activities is not the similarity of movement, but rather the fact that each contributes to building a nest, or a dam, or a food cache. Just as the classification of an object with respect to others helps to describe it to those who are familiar with the other objects, so does the relating of an instance of behavior to its result help to characterize it to those who are familiar with the result.

The designation of the consequences of movements also helps to describe how the organism survives in or adjusts to its environment. The bird by building a nest hatches its eggs with greater certainty and makes surer the continuance of the species. The squirrel by storing nuts obtains a food supply for the winter and makes more certain its own survival. It must be reiterated that the nuts are not stored with a view to the squirrel's survival nor the nest built for the sake of the species. Certain acts are necessary if the animal is to survive, but their consequences never explain them. They are always explained in terms of present construction and present relationship with environment. The squirrel stores its nuts, if you please, because it is a squirrel and because there is an abundance of nuts in the autumn. The question of why it is a squirrel, constructed as it is, of why any organism is so constituted that its behavior is for the most part beneficial to itself must be answered from conditions anteceding and leading up to that organism. The essentials of this type of answer will be given in the course of this book. For the present we are interested in pointing out that the designation of the consequences of an act

has descriptive but not explanatory value. Behavior is not first of all purposive or bio-social, but rather mechanistic or bio-physical.

The refusal to admit the validity of explanation in terms of consequences should not be considered a denial of the descriptive value of stating the consequences nor a refusal to concede that man makes plans and executes them. Certainly my actions at this moment, my thinking and typing are a part of my plan to complete this book and place it before a group of readers. But this plan is a set of verbal activities which is the outcome of various conditions and situations. It has causes or antecedents, and, once formulated, it in turn becomes a contributing factor in determining further actions, among them my present typing. In a sense I have already completed this book and placed it before my readers. What will in reality happen in the future has already happened in my thoughts, in my language responses, and this is possible because I have observed or read about the requirements for having a book published. My present actions are not, however, guided by the future, by their effects; they are determined by my past and present. The questions of whether man plans and whether his acts are directed by their consequences are two separate problems. That actions are guided by their effects the author cannot believe; that men plan the author cannot deny. If to the reader there appears to be any inconsistency here, it is hoped that, as he proceeds, the difficulty will disappear.

THE TASK OF PSYCHOLOGY

Having seen the requirements which are imposed upon us if we are to reasonably expect to understand human behavior, we must gather and organize the required data with the same care and completeness that are used in other branches. The specific tasks are:

- (1) To describe behavior
 - (a) bio-physically,
 - (b) bio-socially.

- (2) To discover the stimulating conditions for the responses described.
- (3) To account for each bit of behavior
 - (a) in terms of structure, as demanded by the postulated principles,
 - (b) in terms of the nature of the fertilized ovum and past environment as demanded by the corollaries.

Any instance of behavior whether displayed by man or by an inanimate object may be studied from these three angles. Suppose one knew nothing about the ignition system of an automobile and that he noticed the movement of the hand of the ammeter on the dash. He would first note the direction and rate of its movements. If further interested, he would notice a relation between its action and the speed of the engine, *i.e.* he would begin to relate the observed phenomenon to conditions in the environment of the behaving object. Finally, he would set out on the task of accounting for the relation, would trace the connections between the engine and the ammeter and would study the construction of the ammeter.

To account for the effects of environmental conditions is obviously the difficult phase of the task, especially in psychology. The psychologist deals not with a single object but rather with a number of similar structures, each of which is continuously changing. The analysis of the construction of one person at one moment in his life does not enable the psychologist to say what that construction was at other times nor does it tell him the physiological features of other men. With each change in behavior there is a correlated modification of structure, and to discover each structural change would be an impossible task. But since it is environment that is responsible for structural modifications, it is legitimate for the psychologist to explain present actions in terms of past happenings, and he needs, therefore, to discover only the general features of construction and the principal ways in which structure is modifiable.

Fortunately for psychology there is a group of other branches

of science which make a special study of man's structure. These are subdivisions of physiology. Anatomy is a study of gross construction; general physiology a study of the behavior characteristics or physiological functions of cells, tissues, and organs; neurology a study of the nervous system; cytology a study of cells. The methods and results of physical and physiological chemistry are essential to cytology and general physiology, and these two divisions of chemistry are intimately related to physics and general chemistry. Consequently, a complete account of human construction demands a familiarity with the whole field of science. This, of course, is impossible, and so the task of psychology is to assemble from these other branches the findings which throw most light upon human behavior, rather than to do research in the analysis of human construction or to bring together all the data bearing upon man's physical make-up.

In addition to these branches which study man's construction, there is a group which considers the effects of man's actions. This second group is commonly referred to as the social sciences, sociology, economics, political science, history, ethics. In their study they discover what behavior is most significant, *i.e.* most valuable or most detrimental to human welfare. The psychologist may, by studying their results, be saved much valueless effort and may direct his energies into problems of greatest significance.

Psychology may then be said to stand midway between the physiological and the social sciences. Its interest is centered in behavior which is exhibited by an organism studied by physiology and which results in customs and institutions studied by the social sciences. It is aided by the physiological sciences in the task of accounting for human action (task 3a) and by the social sciences in giving a bio-social description of behavior (task 1b). It has as its distinctive task the bio-physical description of behavior (1a), the relating of acts to stimulating conditions (2), and the accounting for instances of behavior in terms of heredity and past experience (3b).

THE PLAN OF THIS BOOK

Since we have all known many people and have lived intimately with a few, it is safe to suppose that we are reasonably familiar with the way man behaves. He is not a rare specimen, and in our study of him we need not fit out an expedition nor introduce him into the classroom for exhibition. Instead of concerning ourselves with description, we may, then, start with the presentation of material essential to explanation. This procedure is the logical one if we are to give a systematic account of behavior. A possible pedagogical objection is that the reader may fail while reading the basic material to see its application to the problems of conduct. We have, however, tried to emphasize the necessity for knowing the characteristics of construction and the principles of development if we are to account for behavior in a satisfactory manner, and we must assume that the reader who is desirous of understanding human behavior wishes this information.

In pursuance of this plan the remainder of Part One will be devoted to the physiological characteristics of man, to securing the materials required in carrying out task 3a. Part Two will be concerned with finding and applying the principles of development, with relating definite acts to heredity and past experience, with meeting the requirements of task 3b. Finally, in Part Three we shall describe and analyze some of the outstanding characteristics and forms of adult behavior, being able to presuppose in this section a knowledge of the general principles of construction and of development.

SUMMARY

We have contended that the nature of the fertilized ovum and environment give rise to physiological structure, that physiological structure acted upon by stimulations exhibits forms of behavior, that each form of behavior or act may be compared to others, and that each has consequences. This book will be built upon the assumption that these relations are true. If so, human behavior is to be studied from five angles: (1) in relation

to heredity and past environment, (2) in relation to structure, (3) in relation to immediate environment or stimulation, (4) in comparison to the behavior of other organisms and objects, and (5) in relation to consequence. Negatively stated, it is not to be studied in relation to the mind.

QUESTIONS AND EXERCISES

1. What is the justification for making assumptions? If one should be found to be untrue, would it have been worthless? If it is found to be true, what are the advantages of having stated it?

2. Find illustrations of the five principles of behavior stated on page 31 f.

3. How does the past live in the present? Specifically how does the past experience of a piece of paper exist in the paper at present? What is the import of your answer for the study of human behavior?

4. Suppose you had a photograph of a house before you. Give an explanation of what you would see in terms of past happenings and then one in terms of what would be present before you.

5. Does the definition of psychology as the study of that behavior which is socially or adjustively significant adequately differentiate psychology and physiology? Are the lines separating the various branches of science sharp and distinct?

6. Mathematics and logic are commonly termed the deductive sciences. They start with a set of axioms or postulated truths and deduce the logical consequences of adhering to the set. To what extent are experimental sciences deductive? Why should mathematicians and logicians feel that it is more objectionable to be inconsistent than it is to start with unproved assumptions?

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CHAPTER 3

CELLULAR CHARACTERISTICS

Man is a multicellular organism, a multiplicity of cells arranged in a definite manner. He is not merely an aggregate of cells, just as water is not a mere mixture of hydrogen and oxygen or a house a conglomeration of bricks. Yet in order to know what man is we need to understand something about the cells of which he is built, just as we need to know something about the building units of a house to know what a house is. We shall, then, begin the task of describing man's construction (the task listed as 3a in Chapter 2) by making a study of the characteristics of cells. Of course, we shall not expect to gain from our study of cells a complete understanding of man's structure, because various cells are highly specialized or differentiated and because their arrangement is as important as are the characteristics of individual cells. To understand man's construction we need to know three things: (1) the nature of cells, (2) how they become specialized and arranged to form a complex organism, and (3) what specialization and organization is present in man. The present chapter and the two succeeding ones will be devoted to these three problems.

An additional reason for starting our study of man with an examination of cells is the fact that they are the simplest of living things, and all living things, from single-celled organisms to man, have features in common. The characteristics of action which set off the animate from the inanimate are usually given in biological treatises as three: (1) irritability, including both sensitivity and motility, (2) growth by synthesis rather than by accretion, and (3) reproduction. In animals there are a greater range of movement and a seeming self-direction of action which

distinguish them from plants. The psychologist is interested primarily in man's sensibility or susceptibility to stimulation and in the movements or changes made in response to stimuli, and he can expect to profit by a consideration of irritability as it is displayed in the simplest organisms. Our interest in cells is, therefore, justified by (1) the fact that they are the building units of man's structure and (2) the fact that like man they belong to the group of structures classed as living.

There are many kinds of cells, and to describe them in detail would be a task far beyond the scope of this book. All sorts, from the simple one-celled animals to the highly specialized cells—nerve, sense, and muscle cells,—have common characteristics. Our limited study can be made with greater concreteness by choosing for consideration one of the less specialized cells, and for this purpose the amoeba proteus serves admirably. Stress will be placed upon (1) the general structural features of cells and (2) the manner in which these account for the reactivity which distinguishes the living from the non-living.

The amoeba is a microscopic ball of protoplasm which swims about by means of pseudopods. It pursues and ingests food particles. It synthesizes the food substances into protoplasmic materials and consequently grows. It moves away from conditions or substances which tend to harm it and so preserves itself. It reproduces itself by division. It is continuously active, darting this way and that. It persists in the direction of a food particle even though the particle may have disappeared, and it goes to one or the other of two food particles which, as far as we can determine, should be equally attractive. It does not, like the dumb ass of literary fame, starve to death between two sources of food. Our problem is to find an explanation of these characteristics.

We may say at the outset that nothing is gained by stating that it is capable of these activities because it possesses life. Those structures which are irritable and capable of growth and reproduction we class as living or as life-possessing struc-

tures. To say that they have these characteristics because they are life-possessing is to say that they are life-possessing because they are life-possessing. We are prepared through the discussions in Chapters 1 and 2 to seek an explanation in terms of construction.

CELLULAR CONSTRUCTION

A. The Static Appearance of the Amoeba.

In relation to man, amoeboid structure is simple; as compared with inorganic structures it is exceedingly complex. The amoeba is not a homogeneous mass of material like a lump of clay but rather a number of distinct substances enclosed within a wall. Under a low-powered microscope the cell wall, nucleus, and surrounding cytoplasm are distinguishable. The exceedingly great complexity is, however, revealed only under the ultra-microscope.

Figure 2 is a diagrammatic representation of the appearance of the amoeba proteus under the ultra-microscope. The cytoplasm is shown to be a liquid in which many droplets and particles are suspended. There are three layers which differ in the prevalence and size of the suspended droplets and in physical and chemical properties. Just within the cell wall (the plasmalemma) the suspended droplets are small and few in number; the layer is highly fluid and is called the hyalin sheath. Beneath this the particles are larger and lie close together, forming what is designated as the plasmagel layer. The term plasmagel is derived from plasma—substance of living things—and gelate. Gelates are forms of emulsoids resembling an elastic solid. Jello is a familiar example. The nature of emulsoids will be considered presently. Within the plasmagel is the plasmasol in which the particles that are revealed are large and scattered about in the liquid. The term plasmasol is derived from plasma and solate, solates being relatively fluid emulsoids. Within the plasmasol is the nucleus which is itself complex and which may be found at one time in one region of the plasmasol and at another time in another.

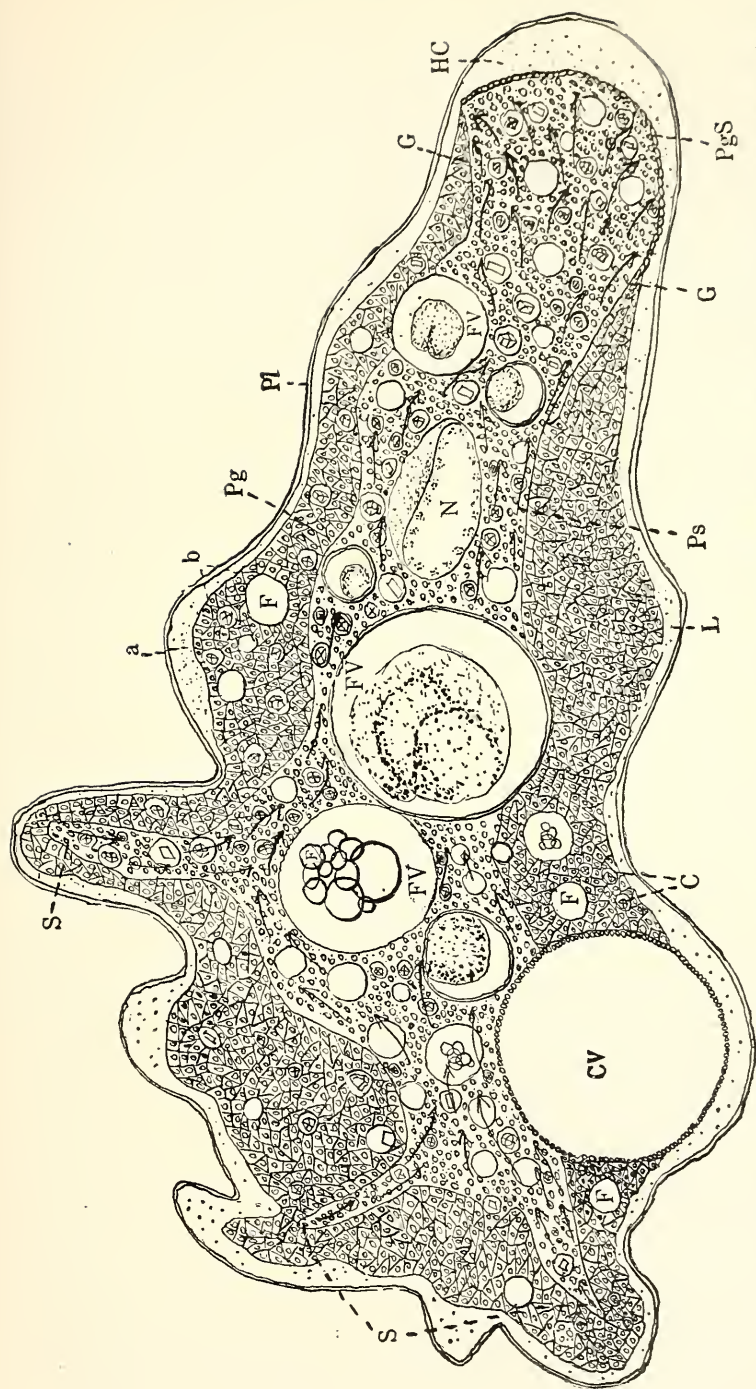


FIG. 2.—Camera sketch of horizontal optical section of *Amoeba proteus*. a, alpha granules; b, beta granules; Ps, plasmasol; Pg, plasmagel; Pl, plasmalemma; HC, hyaline cap; PgS, plasmagel-sheet; L, liquid layer; S, region of solation; G, region of gelation; N, nucleus; FV, food vacuole; CV, contractile vacuole; C, crystals in vacuoles; F, spherical masses of substances formed in vacuoles; arrows, direction and relative rate of flow. (After Mast.)

B. Chemical Characteristics of Cellular Structure.

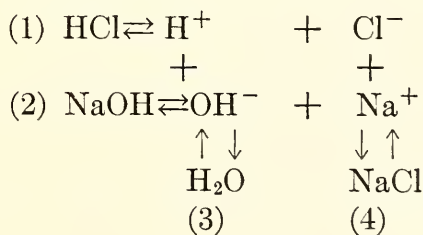
The static appearance of the amoeba gives no real conception of the intricacies of its construction, for it, like any cell, is composed not of a number of inert particles but of chemically active substances. It is a self-walled or self-enclosed chemical system which is termed a protoplasmic system or merely a protoplasm. Protoplasm is not a chemical compound nor are there any chemical elements distinctive of it. The distinctive feature is the organization of the many simple and complex chemicals (electrons, ions, molecules, crystals, droplets) of which it is constituted. There are, then, as many protoplasms as there are distinctive organizations or kinds of cells. When the organization is destroyed, the cell ceases to have its characteristics, ceases to be alive, just as any chemical system or compound ceases to have its properties when its organization is disrupted. The organization of cells is, furthermore, not a static but a dynamic organization. To gain a comprehension of the characteristics of a dynamic organization, we must turn to a brief study of dynamic equilibriums as they are exhibited in the inorganic world.

1. *Cellular characteristics in relation to simple dynamic equilibrium.* The word equilibrium is used to describe the state of an object which is acted upon by neutralizing forces. If two equally strong magnets are placed on opposite sides of a piece of steel, it does not move and is said to be in equilibrium between the two magnetic forces. In a dynamic equilibrium there is in one sense the absence of change, but there is also constant movement as expressed in the word dynamic. Let us suppose that we add hydrogen chloride to pure water. The hydrogen chloride molecules dissociate to give positive hydrogen ions and negative chlorine ions. (An ion is an electrically charged particle which in union with an ion or ions of opposite charge forms a molecule.) Not only does dissociation take place, but there is also a constant reuniting of the ions to form hydrogen chloride molecules. The two actions are described symbolically in the formula, $\text{HCl} \rightleftharpoons \text{H}^+ + \text{Cl}^-$. It is readily seen that the one

reaction tends to neutralize the other, and consequently soon after the addition is made, a certain percentage of the hydrogen and chlorine will be in molecular form and a certain percentage in ionic form. There is constancy or stability in the state of the chemicals; that is to say, there is equilibrium. On the other hand both reactions are continuously taking place, some of the molecules dissociating and being replaced from the union of some of the ions, and some of the ions uniting and being replaced by others arising from dissociation. The three sorts of materials—hydrogen chloride molecules, positive hydrogen ions, and negative chlorine ions—are together in dynamic equilibrium.

At this point a digression seems warranted. We have said that one of the characteristics of organisms is sensitivity. A group of chemicals together in dynamic equilibrium is also sensitive. The equilibrium may be disturbed by adding or subtracting any one of the constituents or by temperature changes. In this case an equilibrium is re-established at a new level, *i.e.* with a different ratio of molecular and ionic constituents. It is evident that the more complex the system the greater the possibility of disturbing it. The sensitivity increases with the complexity. In describing the increasing complexity of chemical systems, we are, therefore, accounting for the difference in sensitivity between organisms and inorganic systems.

To illustrate the complications arising as more substances are found together, let us suppose that we add sodium hydroxide to the system just described. The new conditions are pictured as follows:



The equilibrium of the sodium hydroxide and its ions is expressed in (2). The H ions from the hydrogen chloride and

the hydroxyl (OH) ions from the sodium hydroxide unite to form water and water in turn dissociates to give these ions, as expressed in (3). In the same manner sodium and chloride ions combine to give sodium chloride (common salt), and this again breaks up into these two sorts of ions, as expressed in (4). These four equilibriums are interdependent, and hence the whole system may be considered one complex dynamic equilibrium with greater sensitivity than a simple hydrogen chloride system.

This four-way equilibrated system is relatively simple as compared with the equilibrations existing within a cell and between it and its environment. Four factors contribute to this increased complexity. (1) In cells the chemicals are much more complex than those in the simple inorganic systems, and (2) the number of chemicals involved is greater. (3) The chemicals within a cell interact through the cell wall with the chemicals of the surrounding liquid so that there is not only an equilibrium within the cell but an equilibrium between it and its environment. (4) In cells there are filmy partitions which separate the materials of one region from those of others, while in the inorganic systems one region has the same constituents as any other. Let us next describe the nature of these filmy partitions and then return to a consideration of the complications introduced into the dynamic cellular organization by their presence.

2. *Cellular characteristics in relation to emulsoïd states.* If a drop of mercury is placed in hydrogen peroxide, oxygen liberated from the hydrogen peroxide attacks and oxidizes the mercury and causes the mercury to rust. A thin coating of mercuric oxide (rust) is formed around the drop, and this coat protects the mercury from further attack. Thus a drop of one substance (mercury) is suspended in another substance (hydrogen peroxide) and separated from it by a third material (mercuric oxide). When a quantity of one substance is suspended as small droplets in another substance and the two materials are separated from each other by filmy coverings of a third substance,

the whole system is termed an emulsion. The thousands of filmy coverings enclosing the thousands of droplets within a cell are discernible under the ultramicroscope and are indicated in Figure 2. This, as well as many other facts, indicates that the organization of a cell resembles very closely the organization of an emulsoid.

The characteristics of emulsoids are so numerous and their explanation so baffling that a division of chemistry (colloidal chemistry) is devoted to them. For our purposes it will be sufficient to point out the following facts: (1) In all probability the filmy coverings of the thousands of droplets within a cell are formed in much the same manner as the coating of mercuric oxide is formed about a drop of mercury when it is immersed in hydrogen peroxide, *i.e.* the constituents of the cell are partially oxidized and in this state present a partial barrier to further oxidation. We are all familiar with the fact that soap and water remove oils or fats. Soap is a partially oxidized fat, and in the presence of water soap films are formed. These surround small droplets of oil and hold the droplets suspended in the water. If the water is moving the oil or fat is carried away with it. The explanation is to be found in the characteristics of the three sorts of molecules—water, soap, and oil molecules. (2) In the emulsion of oil in water the molecules of the soap film are definitely organized, as are the molecules of any emulsoid film. The unoxidized end of the soap molecules points inward as indicated in Figure 3. This definite organization gives rise to many important characteristics of emulsoids whose discussion is not relevant to our present problem. (3) In some emulsoids there is more enclosed liquid than suspending liquid. (In the emulsion of oil in water the oil is the enclosed liquid and water is the suspending liquid.) In these emulsoids the droplets lie close together with the result that the whole is a gelatinous, semi-solid mass. In this state the emulsoid is termed a gelate. In other cases there is a greater amount of suspending liquid than enclosed liquid. The whole is highly fluid and is called a solate. Under various environmental influences—temperature changes,

electrical currents, light, jarring or vibration—many emulsoids change from one state to the other.

Protoplasms differ from the simpler inorganic emulsoid systems in several ways: (1) In the emulsoid there is within the

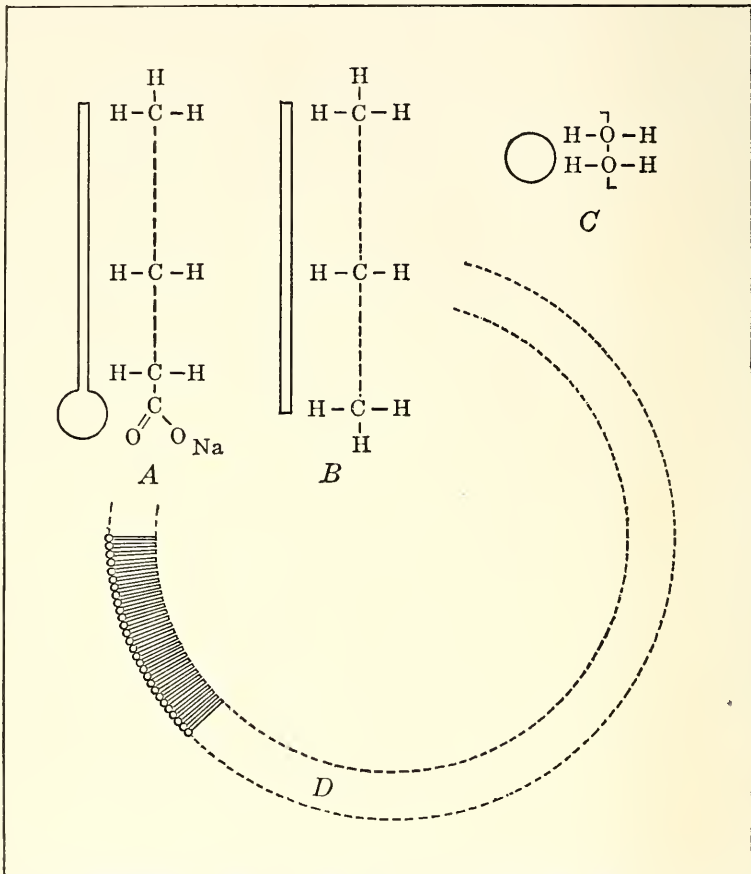


FIG. 3.—Indicating how an emulsion of oil in water through soap is formed. *A*, soap molecule; *B*, oil molecule; *C*, water molecule; *D*, soap film. The oxidized ($\text{O}=\text{C}-\text{ONa}$) ends of the soap molecules cohere with each other and with water, while the unoxidized ends cohere with each other and with oil. In consequence a film of soap molecules forms about a droplet of oil and holds the droplet suspended in water.

droplet only one substance, while in protoplasms there is within any droplet a number of interacting substances together in dynamic equilibrium. (2) In emulsoids each droplet is like

every other, while in protoplasts they differ from each other. (3) In the emulsoid the liquid within the droplet does not interact chemically with the liquid in which the droplet is suspended, while in protoplasts these two liquids interact through the permeable film. (4) In emulsoids the suspending liquid does not have other chemicals dissolved in it, while in protoplasts the suspending liquid has within it many chemicals together in dynamic equilibrium. (5) Emulsoids are not self-walled, while protoplasts are contained in a permeable wall which allows interaction between the chemicals within the cell and those surrounding it. (6) The chemicals of emulsoids are analyzable, while protoplasts have within them chemicals which have not been identified and others whose molecular structure is not known.

By comparing protoplasts with emulsoids we gain some conception of the complexity of living structures and are disposed to believe that, if we had a thorough comprehension of cellular construction, we should have a basis for the explanation of cellular performance. We are led to believe that the secrets of life may yet be revealed from research into the physico-chemical properties of cells. This may not mean that it will be possible to duplicate cells, for even when the essential factors in cellular organization are known, the problem of producing and combining those factors will still remain. The information now at hand, however, enables us to account for many of the more important characteristics of action, as we shall now try to show.

CELLULAR ACTIVITY

A. Relation of Cell and Environment.

The fact that the complex chemical system within the cell interacts with the liquid medium in which the cell lives means that there is a dynamic equilibrium between the cell and its environment. This, in turn, means that there is no cell apart from its environment, just as there are no hydrogen and chlorine ions apart from hydrogen chloride. In a sense the cell and its

environment are one or at least parts of one system. Yet we find it convenient to distinguish between them just as we distinguish between a mountain and a valley. Without the one the other does not exist. There is constant activity within the cell and continuous influence of its environment upon it. Any change in the environment, whether it be in the amount or state of any of the chemicals in the environmental medium, in temperature, in the amount of light, in the amount and direction of electrical currents, means a readjustment within the cell, just as change on the ionic side of a hydrogen chloride equilibrium means a change on the molecular side.

B. Disintegration and Synthesis.

In speaking of the cell and its environment as the two sides of a dynamic equilibrium, we imply that there are two opposed sorts of actions continuously taking place. For one thing the materials of the cell are at all times disintegrating. These disintegrative activities are chiefly chemical reactions of an oxidative and energy-releasing sort and can be accelerated by various oxidative agencies. That they are continuously taking place even when the cell or an aggregate of cells is apparently dormant has been demonstrated beyond reasonable doubt. Carbon dioxide, their end-product, is given off in a measurable quantity from wheat which is in a resting state. (See Tashiro, *A Chemical Sign of Life*.)

Opposed to these activities are the building up or synthesizing processes. Each cell is continuously taking in through its wall substances from the environment and building them up or synthesizing them into complex molecules characteristic of itself. Many of these synthesizing reactions can be reproduced by the chemist, but not all. He fails in all probability because he cannot reproduce the many catalytic surfaces present in the cell, because he has not as yet isolated some of the complex chemicals that act as specific catalysts, and because he does not know the molecular structure of some of the cellular chemicals. It is, however, only through his study that we shall come to

understand the synthetic activities of the cell. As we have already pointed out, there is no value in doing what we are all tempted to do, attribute the synthetic powers of the cell to its possession of life. Those objects which have these synthetic powers we describe as living or possessing life, and to say that the powers are derived from life is merely to say that the structure is living because it is living. Life is not a source of energy but that state in which a structure is irritable and capable of growth and reproduction. Again the conviction must be expressed that the features of construction hold the secrets of the characteristics of action.

The synthetic and the disintegrative processes proceed constantly and simultaneously, as do the opposed reactions of a hydrogen chloride system. There is constant instability, activity, or life, and also neutralization resulting in stability, equilibrium, or continued organization.

C. Growth or Formative Responses.

When a change in environment occurs, the rate of both processes is altered. The complex substances of the cell are broken down with greater rapidity, but the cell does not fly to pieces as does a stick of dynamite, and does not wholly disintegrate. The energy yielded is used in part in a compensating increased rate of synthesis. The amount of energy may be many times as great as the energy of the stimulating agent, just as the energy of an explosion of gunpowder may be many times the energy of the match which sets off the explosion. Because of the availability of this excess of energy under stimulation, the synthetic processes go on beyond the point of repair with the result that the cell grows. This phase of activity may be called the formative responses of the cell or organism.

D. Locomotion.

In single-celled organisms another part of the released energy is spent in the mechanical work of moving the cell or some of its parts, in producing locomotion. The form of the movement is characteristic of the cell reacting. In the amoeba proteus, a

pseudopod is sent out, and the amoeba proceeds by a peculiar sort of rolling motion. Mast has carefully studied this movement under the ultra-microscope.¹ From his account we may give the following description with the aid of Figure 2.

Under stimulation the plasmagel becomes very thin at some definite region, *i.e.* a hollow tube of plasmagel practically open at one end is formed. This gelate is hypertonic or stretched and exerts pressure on the plasmasol. With the thinning of the plasmagel in one region the plasmasol is forced outward to form a pseudopod as indicated by the arrows. As the plasmasol comes into the pseudopod, it is transformed into plasmagel and adds itself to the open end of the plasmagel tube as indicated at G. As the solate leaves the interior of the tube, the plasmagel in the region opposite the pseudopod becomes plasmasol as indicated at S. This transportation of material would not move the amoeba unless the amoeba were in some manner anchored, just as one cannot walk without the friction between one's shoes and the ground. An anchorage is gained by virtue of the adhesion of the cell wall, the plasmalemma, to the surface of solids on which the amoeba may be resting. (The amoeba is not free-swimming.) As the wall is pushed out in the formation of the pseudopod, it becomes fastened to whatever it strikes and is loosened anteriorly. Thus, the cell wall rolls over the surface of solids, but the amoeba as a whole does not roll. It is as if a spherical shell were rolled while the material within it did not rotate.

E. Discrimination or Adaptive Responses.

From this account of the action involved in locomotion, we may divide stimuli into two sorts. One decreases gelation and causes the sending out of a pseudopod in its direction by breaking down the gelate near itself. The other gives rise to a pseudopod on the side opposite it since by increasing gelation near itself, a pressure is produced which breaks through the less gelated region opposite. We have already noted that in emulsoids many

¹ "Structure, Movement, Locomotion, and Stimulation in Amoeba," *Journ. Morph. and Physiol.*, 1926, 41, No. 2.

environmental influences result in a change in emulsoïd state, in a change from solate to gelate or vice versa. One important factor in determining the emulsoïd state was not mentioned. It is the acidity or alkalinity, the hydrogen-ion concentration, of the suspending liquid. Any stimulus may through chemical action first alter the hydrogen-ion concentration, and the change in concentration will in turn influence the emulsoïd state and cause the sending out of a pseudopod.

In the case of the amoeba those stimuli which cause the projection of a pseudopod toward themselves are for the most part substances which serve as food, and those which determine retreat tend to injure or destroy the amoeba. These locomotor responses, since they are directly concerned with survival, may be termed adjustive responses in contrast to the formative ones. As was true in the case of the mythical beast, so in the case of the amoeba there is no scientific reason for postulating foresight of consequences. Its structure and the stimulating conditions determine its reactions. If its structure had not provided for adjustive responses, it would not have maintained its existence. The problem as to how it comes to have a structure which makes survival possible involves the whole question of evolution, which obviously cannot be fully treated in this connection. The generally accepted opinion of scientists is that in the millions of relationships of chemicals which through the course of the ages have temporarily existed, some have been of such a character as to establish a condition that prolongs the relationship for a greater or shorter time. The ones which persist today are only a very small proportion of those which have in a sense had an opportunity to become established through the millions of years of our planet's existence.

F. Persistence in Action.

We have now seen that a cell is a system, a unit, a pattern, a configuration of physical substances in dynamic equilibrium with its environment. It is, in consequence, continuously active, highly susceptible to environmental changes, and capable

of both formative and adjustive responses. The responses often continue or persist for some time after the cessation of the stimulus, and the same reaction is not always made to a given stimulus. Let us examine these traits of persistence and variability to find, if we may, their explanation.

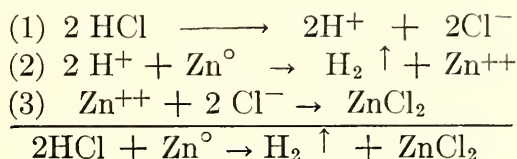
If a food particle toward which the amoeba has sent out a pseudopod is in some manner removed, movement in the direction of the particle continues as if the amoeba were searching for it. This gives its action the appearance of being determined by a purpose, by the desire to obtain food. Just as wood does not stop burning when the match which ignited it is removed, so living things do not cease responding immediately after the direct stimulus is withdrawn. The amoeba, having sent out a pseudopod, is not the amoeba it was. There is within it a new set of activities, and these continue until new environmental relations impose a change or until an equilibrium approximating the original one has had time to be re-established. The opening in the plasmagel layer must be closed before the direction of the movement is changed. Moreover, the stimulus-imposed conditions involve a heightened rate of chemical activity in the pseudopod, and this gives it a temporary chemical dominance over other regions.

G. Unity in Action or Dominance and Subordination.

The dominance of a highly active region over less active ones has been demonstrated in many studies. Child, in his book *The Physiological Foundations of Behavior*, discusses the evidence in detail. Our concern is with the significance and the explanation of the dominance. We have said that stimulation tends to break down the complex chemicals of the cell, to oxidize them. Tashiro² has shown that the rate of oxidation under stimulation is two or three times as great as it is when the organism is in a resting state. Many studies by different methods have confirmed the belief that the pseudopod of an amoeba is more active than other regions.

² *A Chemical Sign of Life.*

The question of how this heightened activity gives the pseudopod a dominance can best be answered by a comparison with a concentration battery. In it, as in the amoeba, materials are being oxidized at two different rates. Suppose that two pieces of zinc are immersed in hydrochloric acid and that one is placed in more concentrated acid than the other. Both pieces are oxidized, the one more rapidly than the other. The action that takes place in these oxidations is expressed in the following formulae:



The real oxidation is expressed in formula (2) in which the hydrogen gives up its plus charge to the zinc, making the zinc positively charged. (Oxidation is by definition the adding of positive charges.) The zinc in the concentrated acid is made positive more rapidly than that in the dilute acid, and hence if the two pieces are connected by a wire, a current flows from the one to the other. The effect of this flow is to make the zinc in the dilute acid more positive than it would be without the connection. As a result, it repels with greater effectiveness the approach of hydrogen ions (unlike charged particles repel each other), and consequently chemical interaction between the dilute acid and the zinc immersed in it is slowed. In other words, the rate of chemical action in one container is dominated by the action in the other.

It has been repeatedly shown that the more active regions in protoplasm are more positive electrically than less active ones, and so we may assume that the apparent dominance of a highly active region is exerted through the resulting electrical currents. When one region is stimulated, conditions throughout the cell are changed. The various regions are chemically and electrically interdependent; the cell is unified. This is another manner of pointing out that the cell is a dynamic organization.

H. Persistence in Action (Continued).

In addition to the stimulus-produced change in emulsoid state, stimulation sets up a heightened activity in the pseudopod, and as a result this region has a dominance over the rest of the amoeba. These two conditions—the opened plasmagel layer and the pseudopod dominance—prolong the movement of the amoeba in the direction in which it has started. Within the physical characteristics of the amoeba are the secrets of its persistence, its seeming desire for food.

I. Variability in Action.

The same two stimulus-imposed conditions explain also the fact that an amoeba does not always react to a given stimulus in the same fashion. When moving toward a food particle, it is not the same amoeba as at other times and consequently should not be expected to respond to other stimuli as it does when not making the movement. A second stimulation in order to determine the sending out of a pseudopod toward or away from itself must first bring about sufficient change to close the existing opening of the plasmagel and to overcome the dominance of the existing pseudopod. In many instances it fails to do this and consequently has no apparent effect even though under other circumstances it would bring about an observable response. As an example, the amoeba proceeding after one particle will disregard others. This effect of one stimulus in deadening or destroying the effectiveness of another is termed *inhibition*. The term might equally well be applied to the effect of one response in preventing another. In other instances the second stimulus tends to produce the same reaction as the first. As an example, if the amoeba is advancing toward a food particle and an injurious stimulus is placed behind the amoeba, its action will be accelerated. This effect of one stimulus in speeding or making more vigorous a response to another stimulus is known as *facilitation* or *reinforcement*.

Persistence and variability in action may, then, like other characteristics be referred to the nature of the organism's

structure. The amoeba does have self-control. The self, however, is a complex and intricate physical structure, or perhaps more accurately is a variable, continuously changing structure.

J. Choice.

The amoeba evidences still another form of self-control. If two food particles as nearly alike as possible are placed at equal distances from the amoeba, it will go to one or the other. The amoeba chooses, and so for that matter does a steel ball placed between two equally strong magnets. An actual steel ball is not perfectly round and so has a slight tendency to roll one way or the other. Furthermore, the surface on which it is resting is not perfectly flat and level, and any unevenness tends to favor or retard the rolling of the ball in a given direction. In these ways a slight initial advantage is given one magnet or the other. As soon as the ball has moved even the slightest distance toward one of the magnets, this magnet has an increased advantage. In an amoeba there is not an equal sensitiveness over the whole surface. The most active region is most sensitive, and it has been demonstrated that surface regions are active in direct proportion to the recency of having been pseudopods.³ Hence; the stimulation from one food particle is practically certain to impinge upon a more active and more sensitive region than the stimulation from the other particle. As soon as this food particle has had a slight effect, the region which it stimulated becomes still more active, sensitive, and dominating, and thus the advantage of this food particle is greatly increased while the chances that the other particle will be effective are rapidly decreased.

SUMMARY

In this chapter we have been concerned with comparing simple living organisms and inorganic systems. We have sought the source of the supersensitivity of organisms and the explana-

³ See Hyman, L. H., "Metabolic Gradients in Amoeba and Their Relation to the Mechanism of Amoeboid Movements," *Journal of Experimental Zoölogy*, 24, 55-99.

tion for the forms of action evoked by stimulation and for the traits of persistence, variability, and choice. We find in living things not the addition of some new force or substance but rather a complexity of physico-chemical structure which determines complexity and intricacy of behavior. We find (1) that there is continuous activity, a dynamic equilibrium obtaining between organism and environment, (2) that a stimulated region is made temporarily highly active, and (3) that the highly active region is most sensitive and controls or dominates others, *i.e.* acts as head. The second and third rule will be especially helpful in dealing with problems to be met shortly. Although the problems of describing how multicellular organisms like man evolve from single cells and how the whole group of cells is organized so as to make an integrated organism are ahead of us, we are inclined to feel that man's irritability, persistence, variability, and choice are essentially similar to these traits as found in simple organisms, and consequently that we are laying the proper foundation for accounting for man's actions.

QUESTIONS AND EXERCISES

1. Does the presence of simple living organisms denote a step or a break in the evolution of electron-proton organizations, *i.e.* is there a principle or a force in living organisms not found in the inorganic world? Support your answer.

2. We have said that a cell is a system, a unit, a pattern. The parts of a complex structure may be bound together in a mechanical fashion as in an automobile or they may be unified in other ways. How are the regions or parts of an organism integrated?

3. It is commonly said that in a cellular response there is first an excitation by the stimulus, then a propagation of the disturbance, and finally a response or movement. Why do we not speak of excitation and propagation in inorganic systems?

4. Is the distinction between a formative or vegetative response and an adjustive one a sharp distinction? Justify your answer.

5. Is there survival of the fittest in the inorganic world as well as in the organic? Does the survival value of a structural feature explain the origin of that feature?

6. Write a paper on the nature of life.

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CHAPTER 4

GROWTH AND ORGANIZATION OF MULTICELLULAR ORGANISMS

The formative or growth responses in unicellular organisms are insignificant as compared with these activities in multicellular structures. In the amoeba there are only slight variations in structure with differences in age. Throughout its life it is much the same animal. Any region may at any age become a pseudopod or temporary head but will in a relatively short time lose its dominance to some other part. On the other hand, the changes in construction of multicellular organisms from conception to death are very marked. Practically all start as a single cell, and in the course of divisions of this cell and the re-divisions of the derived cells there is built up a complex adult structure characteristic of the species from which the germ cell is derived. The question arises as to what determines the direction of this growth, as to why the development from the germ cells of one species gives rise to adults of that species.

In reading, one may be inclined to think that biologists are divided into two groups on the basis of their answer to this question. One group studies the structure of the germ cells of various species and finds differences in them. These differences are then stressed as determinants of the nature of the adult which arises from the germ cell. Another group studies the influence of various sorts of environments and finds that the course of development may be markedly altered by the environment of the developing organism. These variations lead this group to stress the determining influence of environment. Both points of view are useful in promoting programs of research, but the findings from one do not exclude those from the other. Heredity and environment are not antithetical. It is not heredity *or* environment that determines the nature of growth, but

heredity *and* environment. You would not be pleased, for example, to have your hostess inquire whether you would have sugar or cream for your coffee, especially if you desired sugar and cream. If, as was maintained in the preceding chapter, growth is a response to stimulation, the form of the response is determined not only by the nature of the stimulating conditions but also by the character of the structure stimulated, and if all living things are in dynamic equilibrium with their environment so that organism-environment is really one inseparable system, it becomes immediately clear that one may never speak of heredity alone or environment alone. Furthermore one may never speak of one or the other as determining a given percentage of the direction of growth. No object, organic or inorganic, has existence apart from the rest of the universe.

THE RÔLE OF HEREDITY

Each multicellular organism starts from a cell more or less different from those which give rise to others. Some of these differences are directly observable under the microscope and may be termed gross structural differences. Others become visible when the cell is stained with chemicals. Those areas which are stained readily by basic dyes are termed chromatin areas or bodies, and the chromatin areas within the nucleus are called chromosomes. The latter may differ in number, size, shape, and arrangement. The cells, both germ and somatic (of the body), of the biological families show differences in the number of chromosomes; those of the species within a family possess chromosomes of differing sizes and shapes; and those of a given member of a species have within them only a part of the chromosomes of the size and shape characteristic of the species and have these arranged in a manner characteristic of the individual.

Each of the higher multicellular organisms starts from a cell which possesses the number of chromosomes characteristic of his species, but through variations in the size, shape, and arrangement of this number he may initially be a cell quite different from other members of his species. The cell from

which he starts is the result of the union of the sperm and ovum. The sperm carries with it half of the chromosomes present in the cells of the father, and the ovum has half of those present in the cells of the mother. If the number of chromosomes for the biological family is four, four different sperms may come from the father and four different ovums from the mother. Any one of the possible sperms may unite with any one of the possible ovums, and so the fertilized ovum from these two parents may be any one of sixteen possibilities. The number of different gametes (sperms or ovums) possible for each family number is shown in Column 3 of Table 1. The number of different fertilized ovums possible from any two parents in any biological family is shown in Column 4. The human sperm and ovum each carries 24 chromosomes, and two parents might theoretically produce several billion children before any two would start from the same cell. Only in case of identical twins do two children develop from the same set of chromosomes. In such cases both arise from the same fertilized ovum.

TABLE 1

SOMATIC SERIES	REDUCED SERIES	COMBINATIONS IN GAMETES	COMBINATIONS IN ZYGOTES
2	1	2	4
4	2	4	16
6	3	8	64
8	4	16	256
10	5	32	1,024
12	6	64	4,096
14	7	128	16,384
16	8	256	65,536
18	9	512	262,144
20	10	1,024	1,048,576
22	11	2,048	4,194,304
24	12	4,096	16,777,216
26	13	8,192	67,108,864
28	14	16,384	268,435,456
30	15	32,768	1,073,741,824
32	16	65,536	4,294,967,296
34	17	131,072	17,179,864,184
36	18	262,144	68,719,476,736

These chromosome differences are far from being the only known variations in germ cells. They are, however, among the most easily investigated and consequently the most thoroughly studied. The differences in the proteid molecules from species to species and many other basic chemical differences are known, and it is safe to assume that there are many differences both in kinds and arrangements of chemicals that have not as yet yielded to man's research. It seems safe to state that each person starts from a cell which is unique in the history of the universe.

If it were possible for all persons to grow in exactly the same environmental conditions, the adult structures would show dissimilarities which could be referred back to differences existing in the cell from which the person started. But there are environmental differences, and added to the original variations may be differences resulting from environmental influence. In the higher animals the embryonic environment provided by nature is, however, relatively uniform, so that it may be said that the differences in structure at birth are due mainly to initial differences. Let us put this line of reasoning into mathematical form in order to make clearer the basis for the conclusion. (1) Initial germ cell A developing in a particular environment X gives rise to structure M at birth. (2) Initial germ cell B developing in a particular environment Y gives rise to structure N at birth. (3) If X and Y are the same, differences between M and N are functions of differences in A and B. It would, however, be illogical to conclude that the differences in M and N existed in A and B, or to conclude that without X and Y structures M and N would have developed, or to infer that M and N would have been what they are had X and Y been different. In other words, the presence of a particular chromosome does not of itself determine anything with reference to adult structure, but rather, given a definite chromosome arrangement with a particular environment, certain structures will be realized.

Let us next examine the manner in which environment oper-

ates, how from one of these various germ cells many cells of varying characteristics are developed and arranged so as to become the individual as we know him.

THE RÔLE OF ENVIRONMENT

The fertilized ovum in its normal environment grows and divides, and these cells in turn re-divide and so on through countless numbers of divisions. During this process differences in the cells arise. The question of how these differentiations come about, of why a great mass of similar cells is not developed seems to be answerable almost wholly in terms of environment. One chromosome or part of the germ cell does not force its way out in a given direction and having reached the proper place start developing an organ. Rather, in the course of cell multiplication, differences in the environment of the various cells arise, and under the influence of the environmental variations some cells develop one set of characteristics and some another set. At the four-cell stage each cell is very much like any other, and all are nearly equally exposed to the environment of the group. As soon as further division takes place, there are inner and outer cells with a consequent difference in their environments. The activity of the inner cells will to some extent be controlled or dominated by activity in the outer ones. In short, each cell has an environment peculiar to its position in the aggregate, and growth, or the formative responses, will vary in accordance with these environmental differences, *i.e.* differentiation will take place, and the nature of the differentiation will be a function of position. As re-division continues, new positions and relationships arise, and as these come into being, further differentiations are built upon preceding ones.

A. The Rôle of Amount of Stimulation.

One may now ask just what environmental factors are different for various positions. Certainly there is no single environmental condition, but one stands out above all others. It is the relative degree or amount of stimulation, particularly oxidative stimulation afforded by the environment. In other

words, the outstanding environmental differences are fundamentally quantitative rather than qualitative, although qualitative differences may also be present and play a rôle. For example, a frog's head will develop from the region which receives most stimulation. Normally the unattached side of the egg is subjected to most oxidation, and this highly stimulated side gives rise to the most active region, the head. If stimulation on this side is experimentally suppressed or stimulation on the attached side is increased, the head will develop from the attached side, *i.e.* from the side which is subjected to the greater amount of stimulation. Through experimental control even after a certain amount of growth, a frog's head may be caused to develop from any region. In the same manner numerous legs can be produced by proper control at one stage in growth.

Studies of this sort lead to the formulation of a rule, in addition to those proposed in the preceding chapter. We learned there that stimulation gives rise to heightened activity and that the region of higher activity will temporarily dominate activity in others. It is also true that *heightened activity leaves the active region modified in such a manner that it continues at a high rate of activity for some time*. This states concisely the way in which specialization or regional differentiation arises. By way of illustration we may cite an experiment with the soil amoeba. When an amoeba of this sort is stimulated, it sends out a pseudopod much as does the one we have described. If the same region continues to be stimulated for a prolonged period, the gross structure of the amoeba is altered. It will then appear as an animal of a different species, as a flagellate infusorian, whose general appearance is shown in Figure 4. It has a head, and its movements are forward or backward, not in all directions as in the case of the protean form. Its head region is continuously more active than other regions, just as the pseudopod in the amoeba proteus is temporarily more active than other parts. In short, it has become an organism showing specialization of parts. One region is highly sensitive, exceedingly active, and leads and controls the rest of the animal. A difference in

amount of stimulation and consequent activity, a *quantitative difference*, has given rise to the formation of a region which is different in structure and activity, to a *qualitative differentiation*.

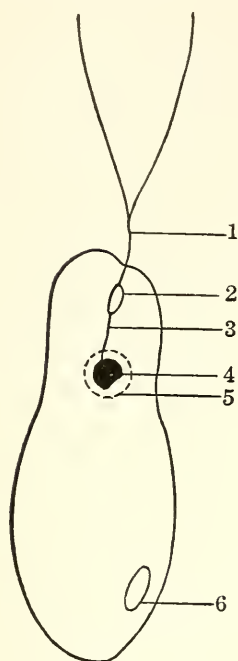


FIG. 4.—Ecito-motor specialization of the soil amoeba in the flagellate stage. 1, flagella; 2, blepharoplast; 3, rhizoplast; 4, karyosome; 5, nucleus; 6, contractile vacuole. (After Herriek.)

Just why a quantitative difference should give rise to a qualitative one cannot be said with surety. It is, however, to be remembered that within any cell numerous specific oxidations and many specific syntheses are taking place. It is altogether probable that a high degree of stimulation speeds certain oxidations and syntheses more than others. In consequence, the constituents of a highly stimulated cell become different in proportions from those in the less stimulated cell. Whatever the explanation of the qualitative change, it seems clearly demonstrated by numerous investigations of physiologists that quantitative changes do give rise to permanent or qualitative ones. As growth progresses in multicellular organisms, those cells which have been highly stimulated during development take on special structures and maintain a high rate of activity. Quantitative differences in stimulation existing during development give rise to more and to less active cells.

Between any two regions differing in rate of activity there are intermediate rates of metabolic processes. There are gradations or slopes in the rate of activity from one region to another and these gradations have been termed *metabolic (activity) gradients*. They arise from differences in the amount of stimulation to which the regions were subjected in development, and from the rules developed in the preceding chapter we may say that the high end of the gradient is most sensitive and that it dominates and controls the lower end. The high end is

electrically positive as is a piece of zinc in the more concentrated hydrochloric acid.

In a complex multicellular organism there are many gradients, and their interrelations give to the organism a definite and unified pattern of construction which determines the forms of action. In the higher animals the more significant gradients are fixed in the nervous system and determine the course of propagation of nervous impulses. In order, then, to understand human construction and behavior we shall want to make a study of gradient patterns with a view to being able to comprehend the human pattern. This study will be included later in the present chapter.

B. The Rôle of Kind of Stimulation.

It is not to be thought from the stress placed upon the rôle of the amount of stimulation that it is the only factor determining differentiation and specialization. As the organism grows, the cells not only receive a definite amount of stimulation, but they also come into proximity to other cells of definite sorts: their position in the aggregate means that they are subjected to a definite sort of stimulation. For example, at one stage of development there is an outgrowth of neural tissue of the head region toward the skin. This outgrowth eventually develops into the eye. Several investigations have shown that the proximity of neural and skin tissue is essential to the eye's development. If neural tissue is grafted under the skin of the leg, a structure approximating that of the eye is formed. It is, then, both amount and kind of stimulation which determine specialization along the lines made possible by the nature of the original cell. The result is the development of the various tissues—sensitive, contractile, secretive, connective, epithelial—and the integration of these into a unified organism. In another section of this chapter we shall describe the specialized organs directly involved in response. The point being stressed in this section is that environment as well as heredity determines organismic development. A definite germ cell is the initial structure of each

person, and in the course of its division and re-divisions there is encountered a multitude of environmental influences which determine the lines along which the various regions shall develop.

THE RÔLE OF PRESENT STRUCTURE

The organism at any time after conception is an expression of the nature of the fertilized ovum and the environments in which it has lived. The past environments in a sense exist in the present structure, just as the past conditions which have affected a piece of paper exist in the present structure of the paper. The longer an organism has lived, the more completely is its structure moulded and the less is it capable of being given new directions of development. Involved in growth is the development of regions of greater and regions of less activity, is the development of gradients, and the cells in the various regions take on particular forms and functions. After this differentiation and specialization have taken place, some cells are more sensitive to, more stimulated by, the environment than others. Consequently if all cells were subjected to identical environments, there would still be different activity rates, and the organism would continue to grow along the lines already initiated. Further growth is determined in part by that which has already taken place, by the past environments as well as by the immediate one.

We can make clear this effect of present structure by citing a series of experiments on developing fish. Under normal conditions the head is more highly stimulated than other regions, and the sides receive greater stimulation than the central plane. Hence the fish develops a head-tail gradient and also one from the sides to the central plane. If in the early stages of development stimulation is reduced at the sides of the head, the eyes develop abnormally close together, the extreme case being one in which only one eye is developed in the center of the head. The suppression tends to destroy the metabolic difference from the sides to the center and thereby to cause the eyes to develop at the center rather than at the sides. If stimulation at the

sides is increased, the eyes develop farther apart than under normal conditions. These alterations in amount of stimulation need not be continued until the eyes are fully developed, but their presence at the time the gradients from side to center are normally established is sufficient. By preventing or accentuating the differences which give rise to these gradients, the course of development which normally takes place on the basis of their existence is altered. A bent given at one time has influence at a future time. Obviously the longer growth has continued, the greater is the influence of past environment through its existence in present structure. One could not change the location of the eyes in the later stages of the fish's growth.

In mammals, growth has been progressing for some months before birth. This insures the presence of a normal environment for the first stages of growth and also produces a structure whose post-birth development is already to some extent determined. The post-birth growth which receives its direction from the gradient pattern, the intra-regional influences, the specialization, present at birth is termed maturation in contradistinction to the modifications effected through the agency of post-embryonic environment.

Often the course of embryonic development and of maturation are attributed wholly to inheritance. We have already seen the fallacy of ascribing any development wholly to inheritance, and have observed that environmental conditions are essential to growth. If, however, it is assumed that the embryonic environment for all members of a species is identical, differences at birth and variations arising in the course of maturation may be referred to differences in the fertilized ovums. Upon those who attribute maturation to inheritance rests the burden of demonstrating this identity. Even though this demonstration were possible, it is obvious that maturation would not take place independently of post-birth environment. Maturation depends upon proper nutrition derived from the environment. We shall later discuss it in relation to the development of structures involved in unlearned responses.

THE LINES OF SPECIALIZATION ACHIEVED

It was stated in the section on the rôle of environment that as growth progresses there is a development of various kinds of tissues and organs and an establishment of a gradient pattern. We shall now consider the nature of the resulting organs which are directly involved in response and then shall make a study of gradient patterns.

A. Specialization for Contraction.

1. *Striped or skeletal muscles.* During embryonic growth most organisms achieve a construction which permits them to live in the post-embryonic environment, to make adjustive responses. These responses are executed by muscles which are aggregates of elongated contractile cells bound together by connective tissue which passes over into and becomes the tendons. The arrangement of the cells is such that their contractile effects are additive, and by these effects the muscle is shortened. In most cases the tendon at one end is attached to a part that cannot be moved by a pull of that tendon, while the one at the other end is attached to a movable part of the skeleton. If a sufficient number of cells contract simultaneously, a skeletal movement results. If only a few contract, the result is merely a tension on the tendons. This latter sort of muscle contraction is called muscle tonus, or in a specific case a tonic response.

The muscles are grouped about the skeletal parts in pairs, one muscle pulling the part in one direction and the other in the opposite direction. More than one pair are usually attached to the same part so that it, through simultaneous or seriated action of the various attached muscles, may be moved in several directions. For example, if the shoulder be considered the center of a sphere, the arm can be moved to the position that would correspond to any one of the radii of one-half of this sphere. The number of skeletal movements made possible to man by the nature of his skeleton and the manner in which his muscles are attached to it is extraordinarily great, many more than is permitted by the skeletal arrangement of other animals.

2. *Smooth or visceral muscles.* In addition to the skeletal muscles are the smooth muscles. They are groups of contractile cells quite different in appearance from the striped muscles. The cells are less elongated and not as well adapted to contraction. These muscles form the walls of a tube as in the intestines or blood vessels, or the walls of a hollow sphere as in the stomach or heart, or make a punctured disc as in the iris of the eye. The cells may be so arranged that contraction lessens the size of the enclosure while their relaxation allows it to enlarge from internal pressure; or they may be arranged so that contraction of one group lessens the size of the enclosure and contraction of another group increases it. For example, in the iris of the eye there is an arrangement of muscle cells so that smooth muscles radiating from the pupil are formed and others encircling it are present. Contraction of the former enlarges the pupil, while contraction of the latter constricts it. The action of the smooth muscles is required for breathing, digestion, elimination, circulation, which are obviously necessary for the organism's survival. Action of the skeletal muscles is required for making movements appropriate to external stimulations, withdrawing from hot objects, procuring food, putting on clothing.

B. Specialization for Secretion.

In addition to the muscles is another set of responding organs, the glands, which are organizations of cells specialized for secreting a definite sort of chemical. There are two types, the ductless glands which pour their secretions into the blood stream, and the duct glands whose secretions are poured into some body cavity such as the mouth or stomach or to the surface of the body.

C. Sensory Specialization.

Muscles and glands are set into action by impulses coming into them from the nervous system, and nervous impulses are started from the sense organs when these are excited. Preceding and leading up to a response there is first a *stimulation*, next an *excitation* in a sense organ, next *impulses* conducted through the

nervous system to the muscles and glands, and finally a *contraction* of muscles with resulting *movement*, or *secretion* by glands. Sense organs are parts specialized not merely for ease of excitation, but for stimulation by particular environmental conditions. The eyes are highly susceptible to light rays but not to other forms of stimulation; the ears are sensitive primarily to sound waves. A sense organ is not merely an aggregate of susceptible sense cells but includes other specialized cells and tissues organized in such a way as to facilitate reception of stimuli. These cells and tissues, since they are aids to excitation rather than excitable tissues, may be termed *accessory apparatus*. In the eye the lens is essential to the focusing of the light rays upon the sense cells, the rods and cones in the retina.

D. Specialization for Conduction.

The distance between the sense organs and the muscles, a distance that is necessarily great when the organism is large, is bridged by the nervous system, an organization of cells characterized by long processes or fibers. A stimulation to any portion of the long cell sets up a disturbance which is rapidly conducted throughout the length of the cell. In man this disturbance is propagated at the rate of 120 feet per second.

From many studies it has been found that the disturbance or impulse involves heightened chemical action and electrical change. The Nernst-Lillie conception of what takes place seems most satisfactory. The stimulation applied at one point sets up heightened chemical activity, and this, as we have seen, gives rise to electrical currents. The resulting electrical currents are effective for releasing heightened activity in an adjacent region. From this activity new electrical currents extending farther from the point of original stimulation are generated, and consequently a wave of heightened activity traverses the length of the nerve cell. Somewhat analogous is the burning of a fuse leading up to a charge of dynamite. The difference lies in the fact that the chemical action in nerve cells influences adjacent chemicals through electrical currents rather than

through the heat generated and that in nerve cells conditions are very quickly, within a small fraction of a second, re-established so that a second impulse may be initiated and conducted. In either case there is no transportation of materials.

In mammals the processes of one type of nerve cell, sensory nerve cells, extend from the sense organs to the nerve centers. An excitation in the sense organs sets up impulses which are conducted over these sensory neurons to the nerve centers. Here the sensory impulses give rise to propagations in neurons within the nerve centers, in central neurons, and these propagations initiate disturbances in cells whose fibers extend into the muscles, in motor neurons.

It is apparent that the nervous system serves to link or connect the sense organs and the muscles so that stimulations affecting the former may influence the latter. If the organism is to survive, a given stimulation must be followed by an appropriate act. Hence, it is necessary that the impulses arising in the excited sense organ be conducted to the proper set of muscles. When heat is applied to the tips of the fingers, a muscular action causing flexion rather than extension is demanded. This requires that there be features in the organization and characteristics of the nervous system to account for the direction which the nervous impulses take. In the next chapter we shall present a somewhat detailed description of the human nervous system, but first let us determine in a general way the features of multicellular organization, especially as they are revealed in gradient patterns.

GRADIENT PATTERNS AND THEIR FIXATION IN THE NERVOUS SYSTEM

In discussing the amoeba, we made the statement that it was a unit, a pattern, a system, a configuration of physical substance. This statement applies equally well to any organism. The unity is achieved through the intra-regional influences which are exerted in accordance with the activity or metabolic conditions in the various regions, or, if you will, in accordance with the

gradient organization. In seeking the integrative factors, it is, therefore, necessary to study the activity levels and to try to conceive the pattern which results from their interrelations. The material required can best be presented by describing the types of gradient patterns found in different animals.

A. Radial Pattern.

If we conceive an amoeba in an environment that is uniformly active over the whole surface, any point on the surface would be more highly stimulated and more active than the interior. Each radius would be a gradient sloping from the surface to the center. All gradients could be referred to a point. Among multicellular organisms the jellyfish is an example of this type of pattern. The fact that it is more disc-like than spherical means only that

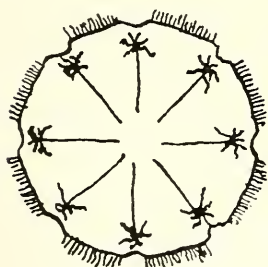


FIG 5.—The nervous system of a jellyfish. (From Max Meyer.)

certain radii are missing and not that the pattern is fundamentally different from that of the amoeba. Viewed from the top, the jellyfish shows the sensori-neural construction indicated diagrammatically in Figure 5. Propagation is inward along the radii. The fact that the neural fibers have grown inward illustrates how a gradient existing during development determines the form of specialization and how this specialization makes permanent the gradient. That the direction taken by the growing axon is determined by the environmental conditions which control metabolic rates, has been shown by Kappers, Child, and others.

B. Radial-Axiate Pattern.

The amoeba is in reality never under uniform stimulating conditions and in consequence always has a pseudopod with a gradient from this region to others, *i.e.* from the most highly stimulated region to the less stimulated ones. We have seen that this gradient may be made to become a permanent part of the amoeba's organization, or, in other words, that the amoeba may become differentiated as to head and tail. A head-tail

gradient, one sloping from the head to the tail along the axis of the animal, is characteristic of most one-celled organisms. In addition there are gradients from the surface to the axis. These may all be referred to a line, the axis, which is itself the chief gradient.

C. Bilateral Pattern.

Add to the sorts of gradients which we have just described those extending from front to back or from back to front, and a third more complicated type of pattern is pictured. Simple earthworms may be studied as illustrative of this pattern. They have a marked axial gradient, the head being more active than the tail. They also have surface-to-axis gradients, radiating ones. In addition there are those extending from front to back, or, more technically, from the ventral to the dorsal regions. The various radiating gradients are to be referred to a plane dividing the animal into right and left halves rather than to a line through the center. The main or head-tail gradient is lengthwise of the plane, and the ventral-dorsal ones are crossways of the plane. All these give rise to and are permanently fixed in bilateral symmetry. The right and left halves of the individual are mirror images of each other, but the front and back halves are not. If the gradients radiating from the plane to the sides are destroyed, bilaterality does not develop. Let us now examine in greater detail the reactive equipment of the earthworm in respect to this whole complex of gradients.

Figure 6 shows the general appearance in diagrammatic form of the earthworm's nervous system which is typical also of all segmental worms, crustaceans, insects, and spiders. The sense cells at the surface have sent out processes of their own to the nerve center of their own segment in accordance with the surface-plane gradients. Each nerve center has connection through motor neurons with the muscles of its segment. The discussion of the factors involved in the growth of the neurons outward would take us somewhat afield. For a discussion of this sort the reader is referred to Child, *The Origin and Development*

of the Nervous System. The important point for our purpose is that there is a gradient from the nerve center outward to the responding organs. In addition to segmental connections and gradients are the intersegmental neural connections, and there

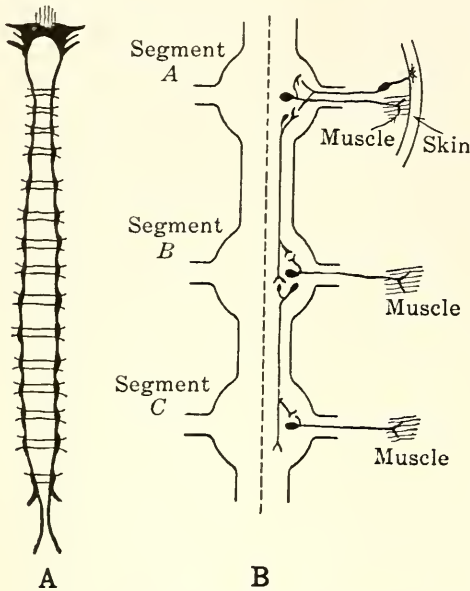


FIG. 6.—The ladder type nervous system. A, gross appearance and B, schema of connections.

is ample evidence to show that there is a gradient along these from head to tail. Through the agency of a nervous system of this sort, a sense cell may set up propagations to the muscles of its own segment and to the muscles of segments posterior to itself. In other words, a sense cell may control or dominate these muscles. The behavior of the earthworm is fully in accord with this explanation. For example, if an earthworm is cut in half, the anterior part crawls away as if nothing had happened. The sense cells affected cannot influence to any extent muscles anterior to themselves. To conceive propagation going up a gradient is like conceiving a ball rolling up hill. Since the excitation is itself a heightened metabolism, the region excited may be made temporarily more active than other regions which are higher in the gradient, and thus propagation may to some extent extend up a gradient. In contrast to the behavior of the anterior half, the posterior section will wriggle for some time from the violent stimulation. The sense cells affected are anterior to the muscles of this part, and so set up propagation to them. After a time this half will crawl away also, the section that was middle usually acting as head. The middle is in most cases

higher in metabolism than the tail and so is the controlling or head end when removed from the influence of the true head. In fact in the simple worms the pattern of organization for each half is little different from that for the whole, and each can get along fairly well by itself.¹

D. Super-Bilateral Pattern.

From the earthworm upward in the animal scale, the nerve centers of the head are increasingly large in proportion to the total mass of the nervous system. In the invertebrates and in fishes, amphibians, and birds this relative increase in the size of the centers of the head region is an expression of the increased number and importance of sense organs located in the head. In these biological families the nerve centers of the head, although they are large enough to be termed brains and although they have some of the characteristics of mammalian brains, remain in large part segmental centers providing the same characteristics of behavior found in the earthworm, *i.e.* segmental or reflex action together with a slight head dominance.

In the mammals there is the development of what is foreshadowed in the amphibians, the development of a cerebrum which is not a center for any one group of sense organs but rather a center for all. The cerebrum is progressively of greater relative size and importance from the simplest mammals up to man and dominates activity in the rest of the nervous system. Its presence gives a gradient pattern which is best termed a super-bilateral type. Animals which possess it have an organization similar to that of the earthworms, a bilateral symmetry, and in addition have the cerebrum and its neural connections. The features of its construction and its importance in behavior can best be discussed after we have made a study of the human nervous system. At present it may be said that it provides for

¹ An interesting fact is that the posterior half will regenerate a new anterior half similar to the one removed. The study of regeneration is a valuable method of studying the development of organisms and affords considerable evidence in support of the rules of development which we have stated in this and the preceding chapter.

development of behavior on the basis of individual experience, for learned behavior. The behavior of those animals in which it is absent is for the most part reflexive or unlearned. Even birds profit little from experience, although they have relatively large brains. We find in them little cerebral development.²

SUMMARY

The structure of an organism is at any time the resultant of the nature of the fertilized ovum and past environment. The ovum from which one individual originates is in many respects different from others, and in addition to these initial differences are those produced by environment. Environment causes differentiation through its control of the rate of activity. A heightened rate leaves modifications which cause a continuance of the heightened rates. By virtue of the variation in exposure, different metabolic levels, or gradients, are established, and through the dominance of the more active over the less active regions unity or integration is achieved. The gradients become fixed in the nervous system, and consequently a thorough study of the organization and characteristics of this system is essential to the understanding of adult behavior.

QUESTIONS AND EXERCISES

1. If my present structure is an important factor in determining my future structure, do I not to a large extent determine my own future? Could you not make out as good a case for predestination as for self-determinism? Are the two views antithetical or merely the outcome of special emphasis? Find cases in which disagreements result from the emphasis by each side upon only a part of the truth.

2. What is implied in the phrase, unfolding of hereditary potentialities?

3. What is the justification for talking of hypothetical conditions as, *e.g.* of an amoeba in a uniformly active environment or of a universe composed of all like-signed particles?

4. Fill in the details of an analogy between the ignition system of an automobile and the nervous system of a multicellular organism. In what respects does the analogy break down?

² See Herriek, C. J., *Neurological Foundations of Animal Behavior* for a comparative study of the nervous systems along the animal scale, and a discussion of these in relation to gradient patterns and conditions.

5. Children often set dominoes on end in a row and then strike the one at one end. Compare the result of this action with the propagation of a nervous impulse.

6. Write a paper on gradients and gradient patterns, their origin, nature, and significance.

REFERENCES

See bibliography for Chapter 3.

CHAPTER 5

THE SENSORI-NEURAL EQUIPMENT OF MAN

In the two preceding chapters we saw that an organism is a continuously active structure in dynamic equilibrium with its environment. An environmental change is followed by excitation, propagation, and movement. Upward along the animal scale there is an increasing degree of specialization for these three functions, the apex being reached in man. Having gained a conception of how this specialization comes about and of how a multicellular organism is given unity by it, we are ready to make a detailed study of the specialization in man which makes possible his adjustment to his environment. We shall, however, limit ourselves to a treatment of his sensory and neural systems. True enough, man has a distinct advantage over other animals in the variety of movements made possible by the type of skeleton possessed and the arrangement of the muscles about it. No other animal can move its forelimb as man can move his arm, use its digits as freely as man can use his fingers, or operate its vocal apparatus to produce the variety found in human sounds. Skeletal movements are essential to adjustment, but the skeleton is under the control of the muscles, and these are under the dominance of the nervous system. It is the sensory and neural systems which cause the muscles to act appropriately and in proper sequence and combination.

MAN'S SENSE ORGANS

The sense organs change but little from birth to death and cannot, therefore, be responsible for the changes in behavior, although their functioning is essential to every act. A baby, when affected by the light rays arising from a candle, reaches in its direction. After being burned, he avoids it when visually stimulated by it. There is no reason to believe that activity in

his eyes is different after the burn. On the other hand, there are many reasons for believing that his nervous system is so modified that impulses arising from the visual excitation are conducted to a different set of muscles after the burn. To understand behavior we need, then, a more thorough understanding of the nervous system than of the sense organs. For this reason we shall limit our treatment of the sense organs to a list of the various ones together with the stimuli which excite them and to a description of the characteristics of only one of them, the eye. A full discussion is to be found in practically any textbook in physiology or neurology and in many in psychology.

Each form of energy to which man is sensitive gives rise to nervous impulses through the mediancy of some sense organ or set of sense organs. Each sense organ is specialized for picking up a definite form of energy and initiating nervous impulses, just as a radio set is adapted for detecting definite ether waves and setting up sound waves, or as the mouthpiece of a telephone is specialized for picking up sound waves and setting up variations in the electrical currents of the telephone line. For our purposes we need not describe how this is done. We can accept it as a fact, just as some of us, without knowing the mechanism of a radio set, accept the fact that it performs its task. We shall, however, after listing the sense organs, describe how the eye is constructed and how it functions, in order to give a general idea of how sense organs operate.

A. A List of the Sense Organs and Their Stimuli.

- (1) Those organs which are excited by stimuli whose source may be at a distance.
 - (a) The *eyes*, excited by ether vibrations whose wave lengths are between 390 and 760 millionths of a millimeter (abbreviated $\mu\mu$).
 - (b) The *ears*, excited by air vibrations whose frequencies range between 14 and 30,000 vibrations per second.
 - (c) The *olfactory receptors* or organs of smell, excited by many chemicals whose molecules, being suspended in the air, enter the nasal tract.

- (d) The *end organs of cold*, excited by heat waves leaving the body, whether the heat-absorbing object is in contact with or at a distance from the body.
- (e) The *end organs of warmth*, excited by heat waves entering the body.
- (2) Those excited by stimuli in contact with the body.
 - (f) The *end organs of touch*, excited by pressure on the skin.
 - (g) The *dermis* or pain receptors, excited by extreme heat, cold, pressure, or tissue-destroying chemicals. (The cells of the skin retain the primitive sensitivity of all cells. Strong stimuli are required to excite them, and there is no specialization for a particular sort. The excitation gives rise to nerve impulses in the free nerve endings which are often said to be the pain receptors.)
- (3) Those excited by stimuli arising within the body.
 - (h) The *semi-circular canals*, excited by sudden movement of the head in any direction, or by the abrupt stopping of movement.
 - (i) The *otolith organs*, excited by tipping the head away from a position perpendicular with the earth.
 - (j) The *taste bulbs*, excited by chemicals dissolved in the saliva or other liquids.
 - (k) The *muscle spindles*, excited by contraction of the muscle cells, either by being pinched or by the chemical conditions present during contraction.
 - (l) The *tendon terminations*, excited by being pinched when the tendon is tensed.
 - (m) The *organic receptors* or terminations, excited by various conditions of the viscera, internal organs.

The semi-circular canals and otolith organs are often called the static receptors or organs of equilibrium since the impulses arising from them are distributed in such a manner that we keep our upright position when sitting, standing, or walking.

The organs for the detection of pressure, warmth, coolness, and noxious stimuli are often called cutaneous receptors because of their location in the skin (*cutis*).

The muscle spindles and tendon terminations are stimulated by the organism's own movements and are often referred to as the kinaesthetic (to feel movement) receptors. As a person responds to one stimulating condition, new stimuli may be introduced from two sources. The response directly gives rise to kinaesthetic stimulations, and it may also change the organism's position so that new external stimuli are brought into play. The former type we will call *response-produced or proprioceptive stimuli* and the latter sort *response-derived stimuli*. Both play a prominent part in giving rise to sequences of movements.

Although man's receptor system is elaborate, it does not enable him to detect directly all the forms of energy which the physicist discovers through the aid of his apparatus. For example, we have no receptors sensitive to 22/23 of the known ether waves. In order to detect those produced in broadcasting stations, we must use a receiving set. When man builds an instrument which allows him to detect environmental conditions that do not directly affect his sense organs, he is virtually adding to his natural receptive equipment. In designing telescopes and microscopes, he is supplementing his eyes.

B. The Structure and Functioning of the Eye.

Figure 7 shows in somewhat diagrammatic form a horizontal cross-section of the eye. Its functioning is most readily understood by comparing it with a camera. In a camera the light rays which are reflected from a given point in the scene are brought together or focused upon a definite point of the film or plate. This point-for-point correspondence produces an image of the scene on the film. It requires that a lens be present, that the film be smooth and all parts of it approximately equidistant from the lens, and that no light except that which passes through the lens strike the film. In the eye there is a lens (12 in Figure 7). The other conditions involved in producing an image are provided for as follows. The retina (4) which corresponds to the sensitized film is the inner of three coats. These are held

distended in spherical form by the aqueous and vitreous humors (9 and 14). The middle or choroid coat (3) is heavily pigmented so that no light can reach the retina except as it passes through the lens. The outer or sclerotic coat is very tough, insuring against puncture and expansion. In front of the lens it is modified in texture so as to be transparent and in this region is known as the cornea (8).

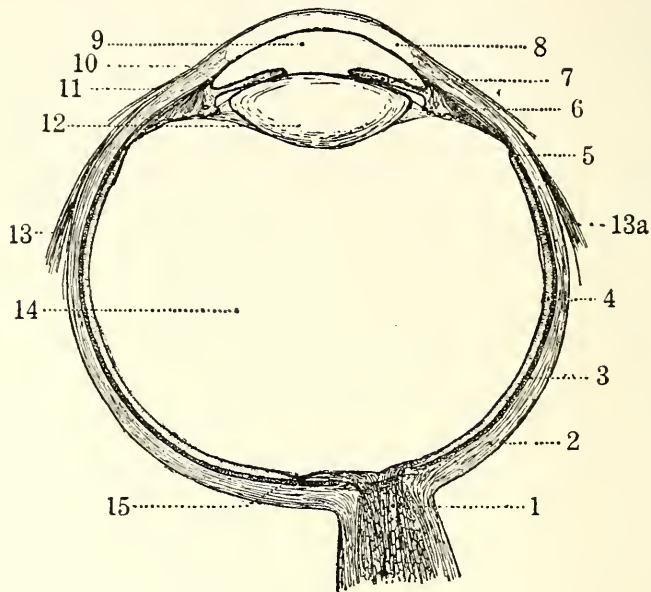


FIG. 7.—Schematic drawing of eye, in cross-section. 1, The optic nerve (really the optic tract); 2, sclerotic coat; 3, choroid coat; 4, the retina; 5, ora serrata, termination of retinal structures; 6, ciliary muscle; 7, iris; 8, cornea; 9, aqueous humor (camera oculi anterior); 10, attachment of choroid to sclerotic forming a fixed point towards which the ciliary muscle draws when contracted; 12, the crystalline lens; 13, tendon of rectus lateralis; 14, vitreous humor (corpus vitreum); 15, fovea centralis. (From Watson.)

In the camera it is necessary to adjust the distance between the lens and film in order to secure a clear image of objects at varying distances. In the eye distance adjustment is provided for by change in the curvature of the lens. This change is effected by change in the ciliary muscles (6) which encircle the edge of the lens. The lens must be more bulged (concave) for

near objects than for far ones, and the contraction of the ciliary muscles is required to produce this shape.

In a camera it is further necessary to adjust for general brightness. This adjustment is provided for both in the camera and the eye by the presence of an iris (7). The iris of the eye is a modification of the choroid coat and is composed of smooth muscles interspersed with pigments which give it its characteristic color. One set of these is arranged concentrically about the pupil (the hole in the iris), and the other set radially. Contraction of the former makes the pupil smaller, and contraction of the latter enlarges it. In the camera a more sensitive film provides for work in dim illumination, and in the eye there are changes within the retina which make it more sensitive in dim light.

The camera is directed toward an object by the photographer, while the eye is turned by action of three pairs of muscles. One pair (13 and 13a) turns the eye to the right and left, one up and down, and the third rotates it slightly.

Up to this point we have described how an image of objects at varying distances, in different illuminations, and under various degrees of illumination, is formed on the retina. The retina, we said, corresponds to the sensitized film which contains chemicals which are decomposed in proportion to the amount of light impinging upon them. After an exposure, points where differing amounts of decomposition have taken place are distributed over the film. These points are spatially related to each other in the same manner as regions of greater and less reflection in the scene are related to each other. In the retina there are photochemical substances, and, just as in the film, there are differing amounts of activity in the various regions of the retina as determined by the amount of light cast upon a given region. The chemical activities excite the rods and cones, sense cells which are distributed throughout the retina. For each image formed there is a definite pattern of excitation in the rods and cones. To make clear what is meant by a pattern, let us suppose that there are six cells. Any one of these might be excited

separately, any two, any three, any four, any five, or all six together. Each of these sixty-two possibilities would be a pattern of excitation. In the eye there are thousands of cells and consequently a possibility of billions of patterns. Excitation in these sense cells starts nervous impulses which are propagated along the optic nerve to the central nervous system and from there are carried to the muscles. Each pattern of excitation initiates impulses in a definite group of nerve cells whose axons (long insulated outgrowths) compose the optic nerves. In this manner there is a definite set of impulses delivered into the central nervous system for each stimulation, and on the basis of this set, impulse are sent into a definite group of muscles. For each pattern of stimulation there is a pattern of response.

This description of the eye will have served to make clear that a sense organ is much more than an aggregate of sense cells and that the possibility of making a variety of responses to various external conditions depends upon the efficiency of the sense organs. The eye is a much more intricate instrument than the camera. Its adjustments are made automatically, and each impression upon its sensitive film is immediately taken off through the nerve cells. In addition to these advantages are those accruing from the fact that man has two eyes. The possession of two organs of vision that work in conjunction makes it possible for him to react more effectively to distance, as will be shown in a later chapter. To illustrate the increased accuracy, the reader might attempt the following. Place a coin so that a little more than half of it rests on a table. Close one eye, and with the other level with the coin extend a finger and raise the edge of the coin. Accuracy will be less marked with one eye than with two.

Our discussion of the eye also points out the obvious necessity of having nerves leading from the sense organs to the responding organs, something to take off the impression made on the sense organs and to determine a response in accord with that impression. We do not see with our eyes any more than a camera sees, although our eyes are essential to our seeing.

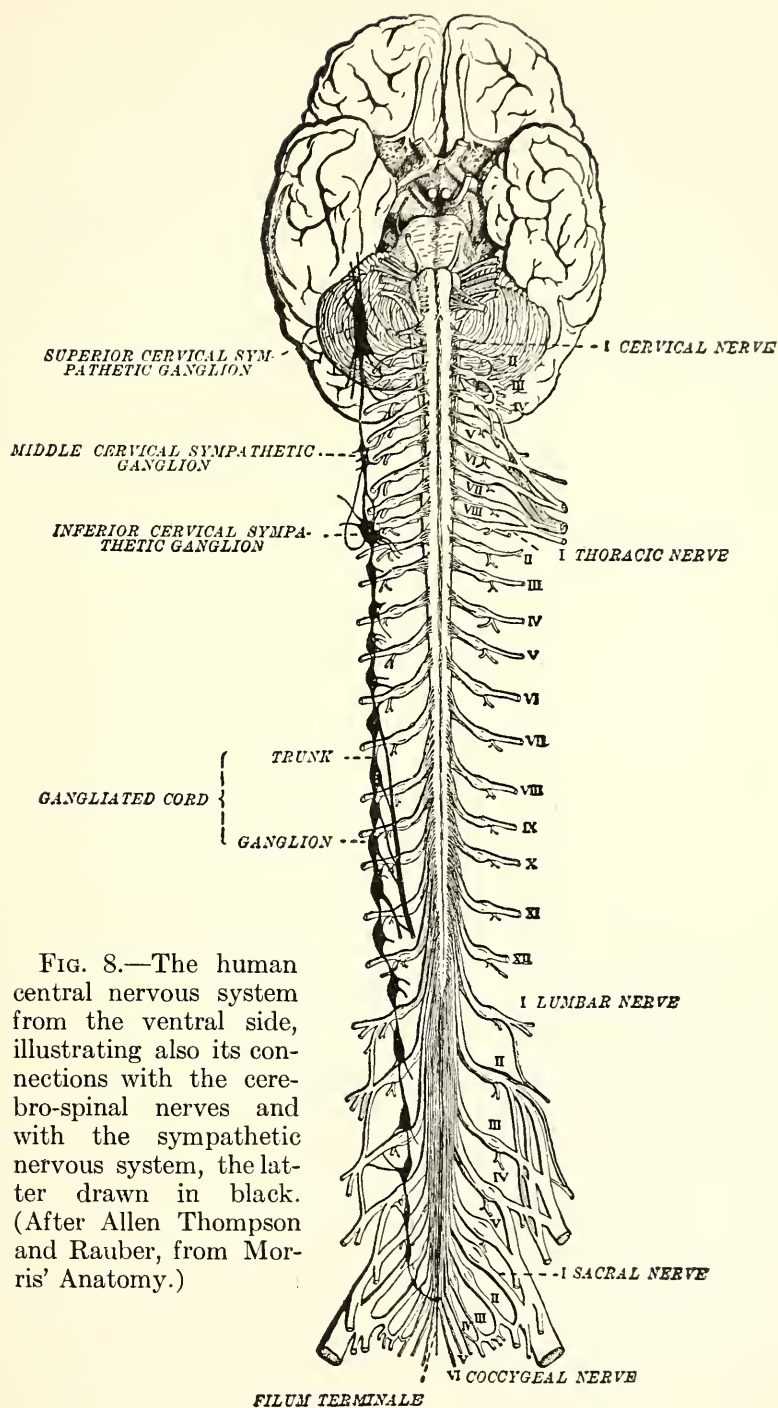


FIG. 8.—The human central nervous system from the ventral side, illustrating also its connections with the cerebro-spinal nerves and with the sympathetic nervous system, the latter drawn in black. (After Allen Thompson and Rauber, from Morris' Anatomy.)

We may anticipate by saying that neither do we see with our brains, although brains too are essential. It does not seem accurate to say that we see with our muscles. Yet this last statement most nearly approaches the truth. Seeing is a reaction, and all reactions are preceded by nervous impulses and sense organ excitations. When we say that we see, we are saying that we, as sensori-neural-motor organizations, are being acted upon by definite stimuli and are in consequence undergoing particular changes.

THE STRUCTURE OF THE NERVOUS SYSTEM

A. Gross Appearance.

Before considering how the nervous system plays its part in behavior, let us examine its gross structural features, *i.e.* mainly those characteristics which may be determined in post-mortem examinations. Figure 8 shows the external appearance of the system as a whole, with the exception of the continuation of the nerves to the sense organs and to the responding organs and with the exception of the autonomic ganglia (in black) on one side. The part into which the thirty-one pairs of numbered nerves enter is the cord. Above the cord is the brain which includes (1) the cerebrum, (2) the cerebellum and pons, and (3) the brain stem. The medulla and the thalami constitute the greater part of the brain stem. These parts are clearly indicated in Figure 9 which is a cross-sectional view. It will be noticed in Figure 8 that there are several nerves entering the brain stem, twelve pairs in all. The nervous system may for purposes of study be divided into nerves, autonomic system, cord, brain stem, cerebellum and pons, and cerebrum. Each of these parts is an aggregate of nerve cells or parts of nerve cells intricately organized. Let us examine rather closely both the structure and function of nerve cells before we consider their organization.

B. The Structure and Functioning of Nerve Cells.

Regardless of its location, a nerve cell in addition to maintaining its life does but one thing, propagates disturbances arising in sense cells toward effector cells. As far as our study is con-

Fig. 9.—Vertical median section of adult brain. 1, medulla oblongata; 2, pons (Varoli); 3, corpus mamillare; 4, hypophysis; 5, optic chiasm (chiasma opticus); 6, anterior commissure (commissura anterior); 7, knee of corpus callosum (genu corporis callosi); 8, septum pellucidum; 9, foramen of Monroe (foramen interventriculare Monroi); 10, massa intermedia; 11, third ventricle (ventriculus tertius) and thalamus; 12, pineal gland (corpus pineale); 13, aqueduct of Sylvius (aqueductus cerebri Sylvii); 14, parieto-occipital fissure (fissura parieto-occipitalis); 15, corpora quadrigemina (lamina quadrigemina); 16, velum medullare anterius; 17, calcarine fissure (fissura calcarina); 18, vermis; 19, arbor vitae; 20, corpus medullare cerebelli; 21, fourth ventricle (ventriculus quartus). (From Watson.)

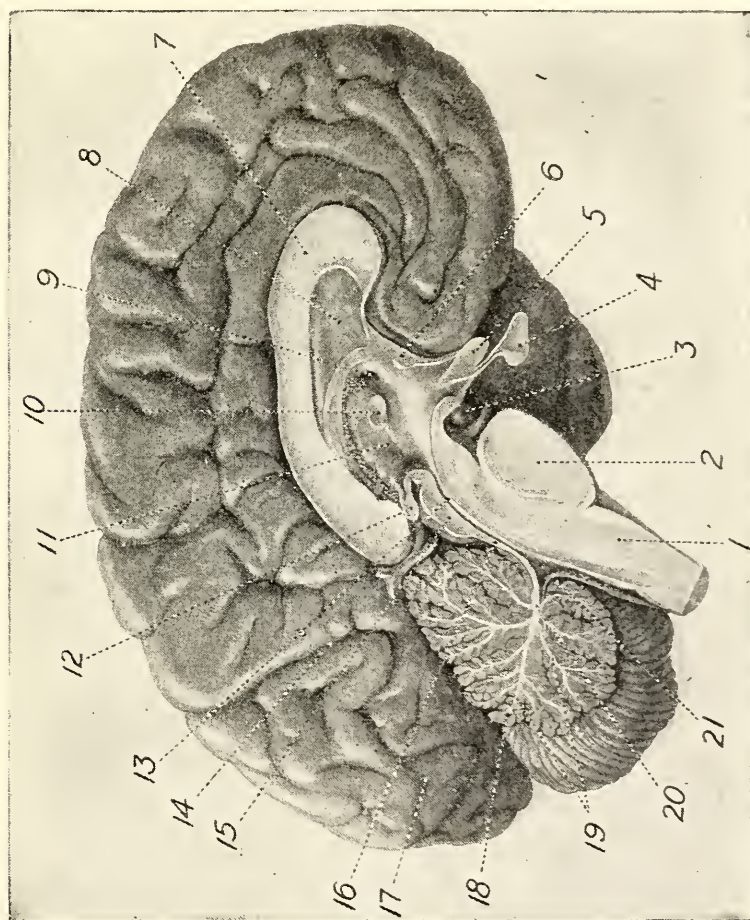
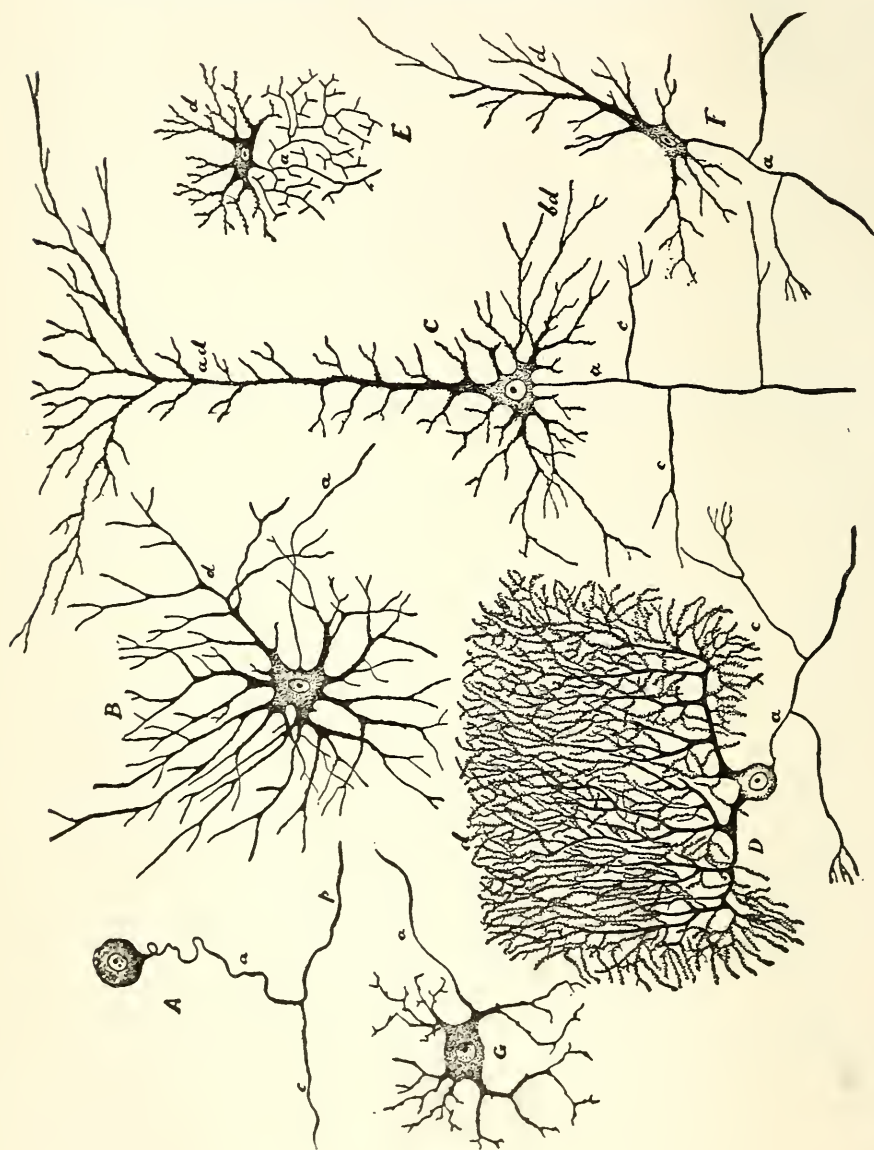


FIG. 10. — Showing some of the varieties of the cell bodies of the neurons of the human nervous system, including the dendrites and small portions of the axons, axon sheaths not included. A, from spinal ganglion; B, from ventral horn of the spinal cord; C, Pyramidal cell from the cerebral cortex; D, Purkinje cell of the cerebellar cortex; E, Golgi cell type II from spinal cord; F, fusiform cell from cerebral cortex; G, sympathetic; a, axon; d, dendrite; c, collateral branches; ad, apical dendrites; bd, basal dendrites. (From Watson.)



cerned, we need only consider the structural characteristics which make possible rapid conduction over long distances. Figure 10 shows some of the varieties of nerve cells, while Figure 11 is a schematic diagram which shows the essential structural characteristics. The arrow indicates the normal direction of propagation. The dendrites (1) lie adjacent to a sense cell or to the endbrushes of other nerve cells. Disturbances in these other cells set up an environment for the dendrites of such a sort that they become excited in the sense and

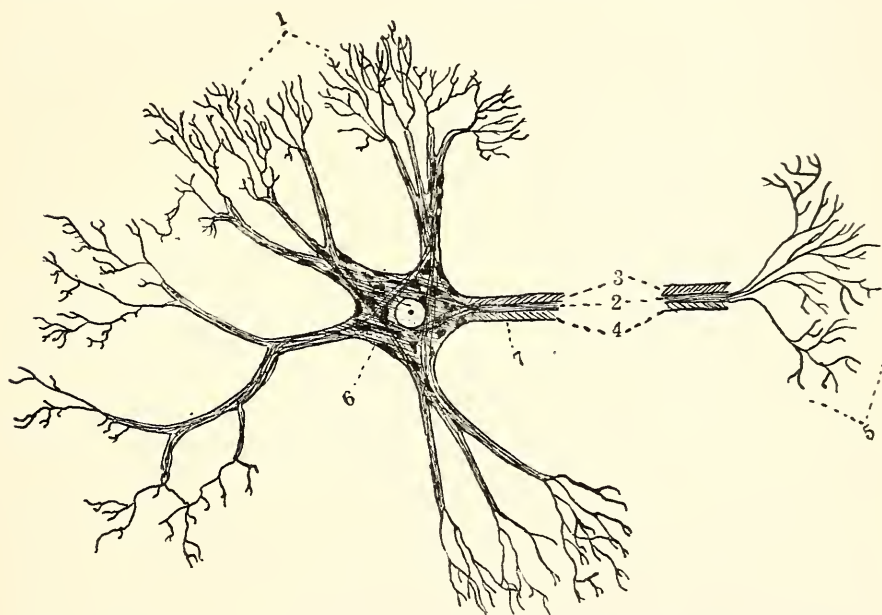


FIG. 11.—A neuron greatly enlarged and somewhat schematized. Explanation in text.

manner in which the amoeba becomes excited by the stimuli of its environment. The dendritic fibrils pass through the cell body (6) which contains the cell nucleus and other parts involved in keeping the cell as a whole nourished. All these fibrils pass out on one side of the cell body and form a bundle (2) which is the core of the axon (7). These fibrils are enclosed in two sheathes (3 and 4), the outside one being a thin tough covering and the inner one a thick fatty coat. These sheathes cease at

the termination of the axon or of any of its collaterals (branches), and the fibrils flange out to form the endbrush (5). The axon and teledendrite (defined later) are somewhat analogous to an insulated electric wire. The fibrils correspond to the fine copper wires, the inner coat resembles the rubber insulation, and the outer coat the protective layer of silk or cotton braid. The endbrushes and dendrites are somewhat similar to the ends of the wire where insulation has been removed for joining. The axons, which may be more than two feet in length, make distance conduction possible. The insulation confines conduction to definite paths instead of allowing a general spreading of the disturbance. The branching of the axons provides for transmission from one point to several specific points, about seven as an average.

The rapidity of conduction in nerve cells is accounted for by four characteristics:

(1) The electrical currents set up by an excitation are confined to one direction and so will excite at a greater distance.

(2) The molecules forming the fibrils are arranged in such a way that there is an electrical conducting medium of smaller resistance than in the less systematically arranged molecules of non-specialized cells.

(3) The protoplasmic systems of nerve cells are more easily excited to heightened activity than those of other cells, and

(4) The rate of activity attained is higher.

The nervous impulse, however, remains the same in nature as propagation in the amoeba. There is a region of induced high metabolism which, because of its electrical positiveness (external negativeness), sets up electrical currents that induce heightened metabolism in adjacent areas. It has long been known that there is a wave of negativity evidenced in the passing of a nervous impulse, but only recently has it been shown beyond doubt that there is also increased elimination of carbon dioxide as an indication of heightened metabolism. The output of carbon dioxide may be two to four times the normal.

C. The Cord, Brain Stem, and Their Nerves.

Having observed the external appearance of the nervous system and having noted that it is an aggregate of nerve cells or neurons, we are ready to attempt to unravel the manner in which the many neurons are related to each other, to seek the way in which the nervous system connects sensitive tissue to responding organs. The simplest connections are made through the cord and brain stem, and consequently we shall first study them. It may be well to recall that neurons are divided into three classes on the basis of their location. Those extending from sensitive tissue to the cord or brain stem are called *sensory or afferent*, those connecting the cord or brain stem with responding organs are termed *motor or efferent*, and those lying wholly within the brain or cord are designated as *central or associative*.

1. *Connections from the sense organs.* It will be remembered that there are thirty-one pairs entering the cord and twelve pairs entering the brain stem. Figure 12 shows a nerve as it enters the cord. Each nerve is in part composed of fibers which arise from sensory cell bodies. These cell bodies lie within the spinal ganglia. The sensory axons extend from the spinal ganglia into the cord, and they constitute the sensory root of the nerve. Sensory neurons do not have dendrites of the sort characteristic of other neurons, but instead they possess long fibers which extend from the sensitive tissue to the cell body. These fibers are like axons in structure, *i.e.* they are long and are coated, but they carry impulses toward the cell body as do dendrites and are called *teledendrites* (long dendrites) to distinguish them from the fine branching dendrites of the central and the motor neurons. The peripheral end of the teledendrite is branching, however. One sensory neuron is diagrammed in Figure 13. The sensitive tissue of a given level of the body is connected by a number of these neurons to the cord at that level, each neuron extending the whole distance.

In three cases this typical form of connection is not present. The sensory cell bodies of the neurons connecting the eye and the ear to the brain stem lie in these sense organs rather than

in ganglia beside the brain stem. The optic and auditory nerves are composed of axons rather than teledendrites. The cell bodies of the neurons leading from the olfactory sense cells are located in the olfactory lobe which is near the sense cells rather than near the brain stem.

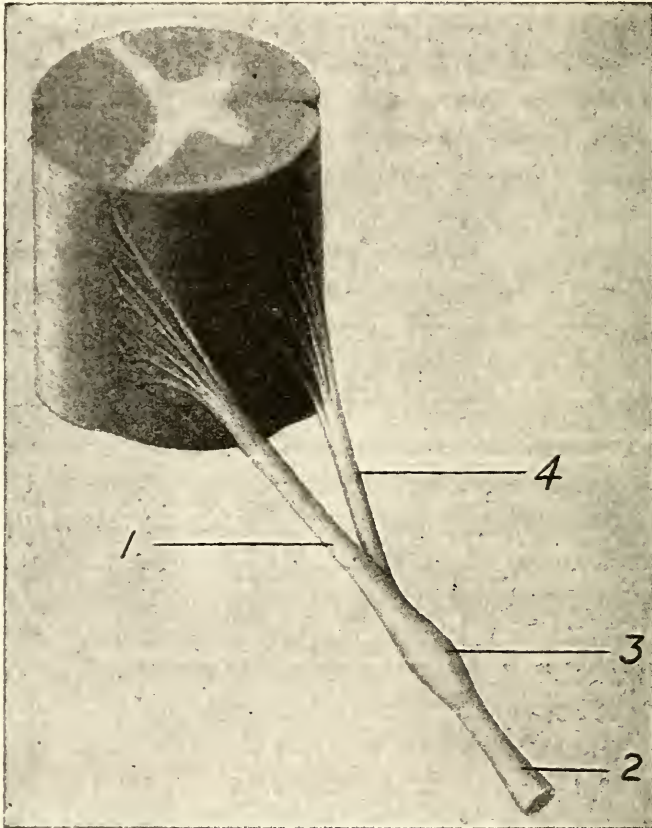


FIG. 12—Segment of spinal cord showing origin of a nerve. 1, afferent or sensory root of nerve; 4, efferent root of nerve; 3, spinal ganglion; this gives rise to the axones which form the afferent root; 2, a spinal nerve; it is made up of motor fibers and afferent fibers (for simplicity the various subdivisions of the nerve such as anterior, posterior, and recurrent are left out). (From Watson.)

2. *Connection to skeletal muscles.* Extending from the cord on its ventral (front) side is the motor root of the nerve. This root is composed of axons of cell bodies which lie in the ventral

horn of the gray matter. Notice in Figure 13 the designation of gray and white matter. These motor axons become a part of the main nerve, and some of them continue onward into the skeletal or striped muscles. One neuron of this type is diagrammed in Figure 13. In this manner the striped muscles of a given level are innervated by neurons whose cell bodies lie within the cord or brain stem at their level.

3. *Connection to smooth muscles and glands. The autonomic system.* Some of the axons composing the motor root, after becoming a part of the main nerve, leave it and enter the autonomic ganglia. (Notice again the parts shown in black in Figure 8 and the neuron designated as pre-ganglionic in Figure 13.) These pre-ganglionic neurons terminate here in endbrushes which make close contact with the dendrites of other neurons whose cell bodies lie in the autonomic ganglia. These latter or post-ganglionic neurons have axons which extend from the ganglia to the visceral muscles and to the glands. Some of these axons enter the main nerve and continue as an integral part of it until they come into proximity with the effector which they supply. Others go to the responding organs in a nerve composed almost wholly of post-ganglionic axons.

This system of pre-ganglionic and post-ganglionic neurons constitutes the autonomic system which may be defined as a motor or outgoing system innervating the smooth muscles and glands. Impulses are propagated in it only as its neurons are excited from within the cord or brain stem.

4. *Connections within the cord.* Each sensory neuron has an endbrush at the level at which it enters, and its collaterals extend up and down the cord with endbrushes at various other levels. Each of these endbrushes inter-twines with the dendrites of a neuron whose parts are wholly within the cord or brain stem. Most of the endbrushes of these central neurons make contact with the dendrites of motor neurons, while some make connection with the dendrites of other central neurons, particularly with those which are involved in pathways to the cerebrum. The former sort of connection completes the neural

pathways between sense organs and responding organs. A completed connection of this type is diagrammed in Figure 13.

We have now described the simplest sort of neural connection. Impulses arising in a sense organ are propagated to the cord or brain stem over a group of sensory neurons, then over a set of central neurons, and finally along a group of motor neurons to the responding organs. In Figure 13 we have shown a representative neuron of each of these three types.

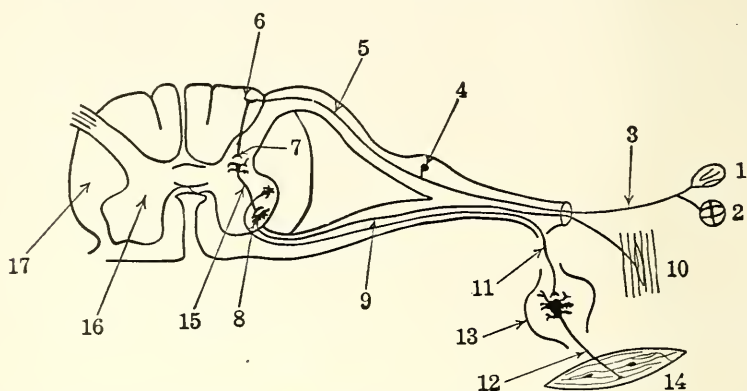


FIG. 13.—Simple neural connections through the cord. 1 and 2, sense cells; 3, teledendrite of sensory neuron; 4, cell body of sensory neuron; 5, axon of sensory neuron; 6, collateral which extends up or down the cord; 7, endbrush of sensory neuron; 8, cell body and dendrites of motor neuron; 9, axon of motor neuron; 10, muscle cell; 11, preganglionic neuron; 12, postganglionic neuron; 13, autonomic ganglion; 14, smooth muscle cell; 15, central neuron, 16, gray matter; 17, white matter.

Each sensory and each central neuron has several end-brushes, and since the collaterals on which these are located extend up and down and across the cord, there are four types of connection completed in the cord and brain stem. The sense cells may be connected with motor cells (1) on the same side and at the same level, (2) on the opposite side and at the same level, (3) on the same side and at a different level, (4) on the opposite side and at a different level. Each of these types is illustrated in Figure 14.

In addition to the connections which are completed in the cord and brain stem, the neurons within these centers provide

parts of the pathways between the sense organs and the cerebrum and between the cerebrum and the responding organs.

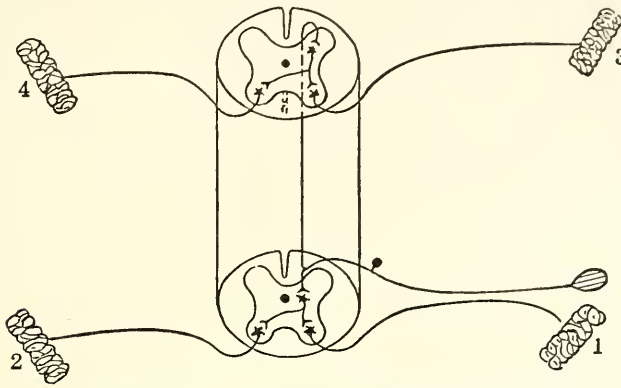


FIG. 14.—Showing the four types of connection completed through the cord.

D. The Cerebrum and Its Connections.

The cerebrum of man is larger in proportion to his body weight than that of any other animal. The two hemispheres fold down over the brain stem, practically enclosing it. The surface is ridged by fissures and gyres so that the surface area is much greater than that of the skull. For a depth of about one-fourth inch the material appears gray to the naked eye and under the microscope is shown to be composed chiefly of endbrushes, dendrites, and cell bodies. This layer of gray is called the cortex. Below the cortex the cerebrum is almost wholly composed of axons whose coating gives this portion its white appearance.

1. *Connection from the sense organs.* The cell bodies of neurons whose axons terminate in the cortex lie in and form the thalami which are two large centers composing the upper portion of the brain stem. Terminating about the dendrites of these thalamic neurons, are axons of other neurons with whose dendrites the sensory endbrushes make contact. In other words, impulses reach the cortex over three sets of neurons in series. They pass first over sensory neurons, then over central neurons to one or the other of the thalami, and finally over a second set of central neurons to the cortex. These ascending tracts usually

cross from one side of the cord to the other, sometimes at the level at which the sensory neuron enters and sometimes in the medulla, *i.e.* sense organs on the right are connected to the cortex of the left cerebral hemisphere and those on the right to the left hemisphere. These two typical ascending paths are illustrated in Figure 15.

Impulses originating in a particular sense organ are most probably delivered into the cortex at a fairly definite location, but from the fact that each sensory and central neuron has several end-brushes, it would seem probable that a sensory point may be connected to several cortical regions. Lashley's studies of the effects on behavior of extirpation of particular areas would indicate that no area can be said to be the only one receiving impulses from a given sense organ. Yet other studies indicate that impulses from the eyes are usually delivered under normal conditions to the regions at the back of the cerebrum which have been designated as visual,

that those from the body enter the somaesthetic regions, and that those from the olfactory, the auditory, and the gustatory receptors enter respectively the regions called olfactory, audi-

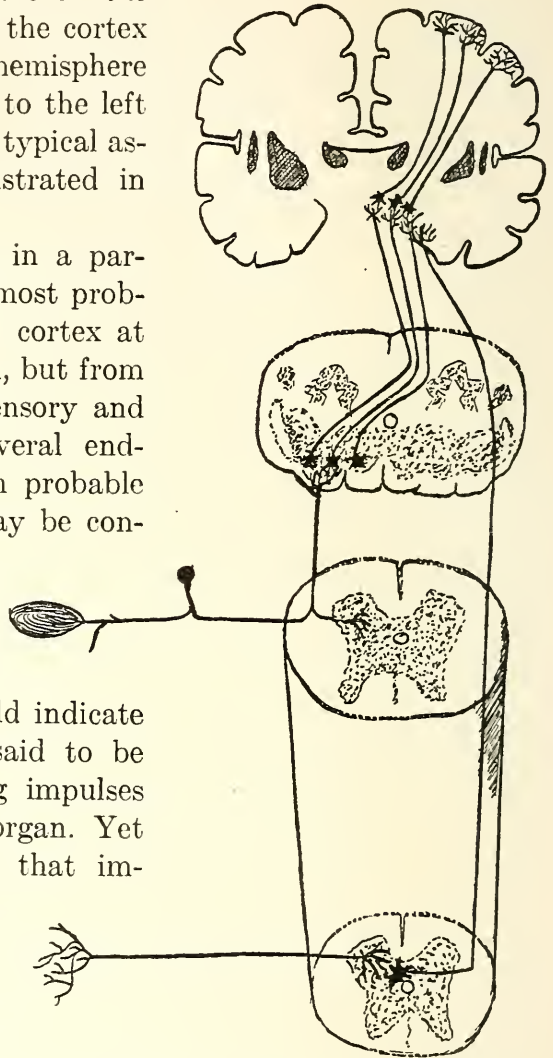


FIG. 15.—Showing schematically the connections between sense cells and the cortex.

tory, and gustatory. Figure 16 indicates the location of these various regions which in general are called sensory projicient areas since in effect the sense organs are here projected on the cortex.

2. *Connections to the responding organs.* In the frontal lobe and more especially in the area designated as motor (see Figure 17) are the dendrites and cell bodies of large neurons whose axons descend into the cord and brain stem and terminate about the dendrites of the neurons leading from these centers

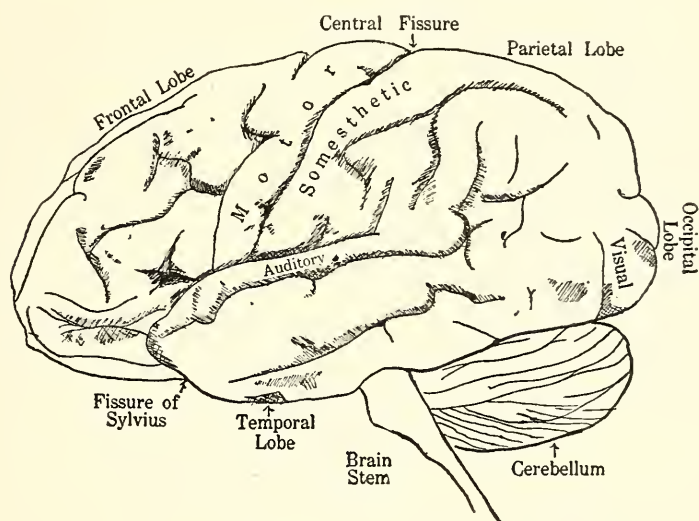


FIG. 16.—Areas of the cortex. (From Woodworth.)

to the responding organs. In Figure 17 a typical connection from the cerebrum to a skeletal muscle cell is diagrammed.

From the frontal lobe numerous axons extend to the cerebellum also. In the cerebellum these neurons make synaptic connection with neurons which in turn form junctions with the peripheral motor neurons. There are, then, direct paths from the cerebrum to the peripheral motor neurons and also shunt paths through the cerebellum. These cerebellar shunts are generally conceded to intensify and prolong motor discharge.

3. *Connections within the cortex.* The sensory and motor areas comprise approximately one-fortieth of the cortex. The other

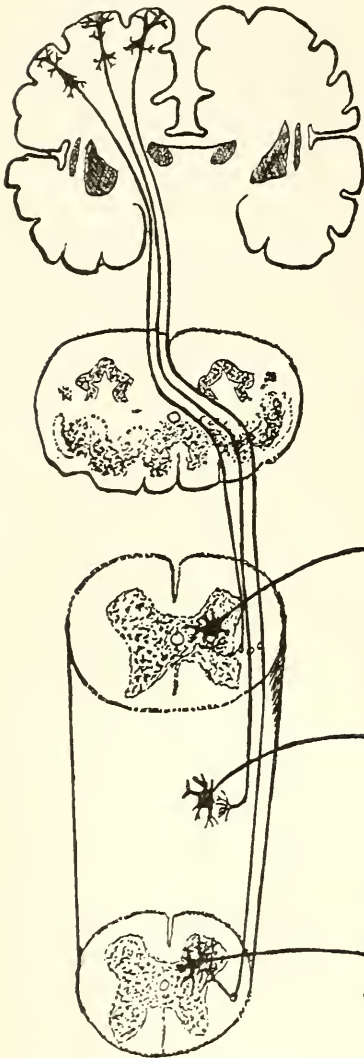


FIG. 17.—Showing schematically the connections between the cortex and striated muscle cells.

cortical regions are termed association areas. In them are the cell bodies of neurons whose axons dip down into the white matter and extend to some other region of the cortex. Figure 18 shows diagrammatically some of these bands of axons.

In addition to these inter-regional connections through the white matter are connections within the cortex itself, the cortical neurons having short axons running through the gray matter to other cortical neurons. In short, the various regions are inter-connected cortically and sub-cortically. In view of the abundance of both types of connections it seems safe to say that any region is linked more or less directly with any other.

4. *Sensori-cerebral-motor pathways.* If impulses are to be propagated from sense organs through the cerebrum to responding organs, the simplest route is one involving six sets of neurons in series. Three sets are located between the sense organs and the sensory projectant areas (see Figure 15), one set from

the sensory areas to the motor area, and two sets from the motor area to the effectors (see Figure 17). These simple connections would involve only about one-fortieth of the cerebrum, and so in most cases we must conceive more complex ones. Instead of passing directly from the sensory area to the motor area, the impulses usually spread from the sensory area to an association area and from this to several other association regions before they finally reach the motor area.

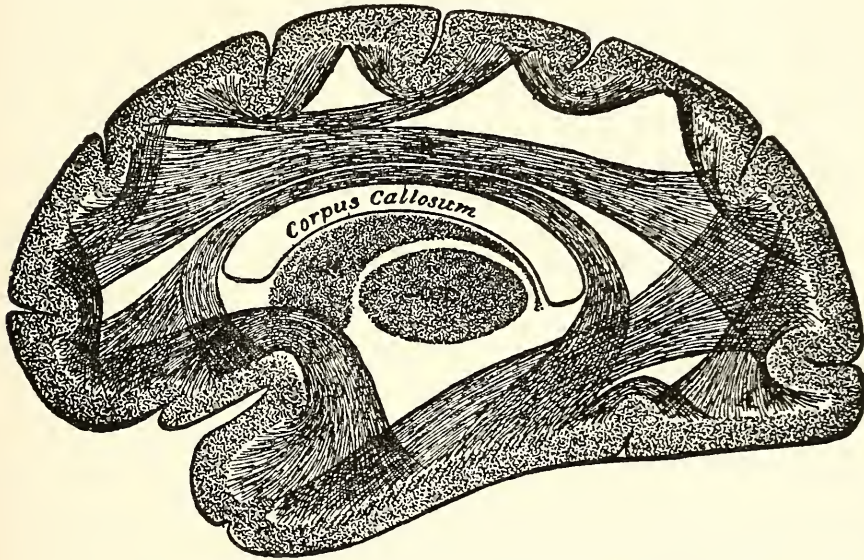


FIG. 18.—Axons connecting one part of the cortex with another. The brain is seen from the side, as if in section. The *Corpus Callosum* is a great mass of axons extending across from each cerebral hemisphere to the other. (From Starr.)

The multitudinous connections in the cerebrum point to the conclusion that through it any sense organ has a possible connection with every responding organ. The converse must also be true, that a responding organ may receive impulses originating in any sense organ.

E. The Cerebellum and Pons.

We have already noted that the cerebellum is involved in the shunt circuits from the cerebrum to the responding organs.

It serves to intensify and prolong motor discharge. Injury to it disturbs muscular co-ordination as in locomotor ataxia. It is also a reflex center for the maintenance of equilibrium, receiving sensory neurons from the static receptors.

F. The Connections of the Nervous System as a Whole.

Suppose that we had a nervous system with the sorts of connection present in the cord and brain stem. A sense cell would have connection with several responding cells for, as we have already mentioned, each sensory and central neuron has several endbrushes. If we take seven as an average number, a given sense cell would have connection with forty-nine effector cells. (See Figure 19.) If the connections involved six neurons in series as in the case of the simplest cerebral arcs, a given sense cell would have connection with 18,807 effector cells. If the connections were made through ten neurons in series, then the number of responding cells with which connections could be made would be 40,493,607. This reasoning is another manner of reaching the conclusion that *any sense cell has connection with any effector cell.*

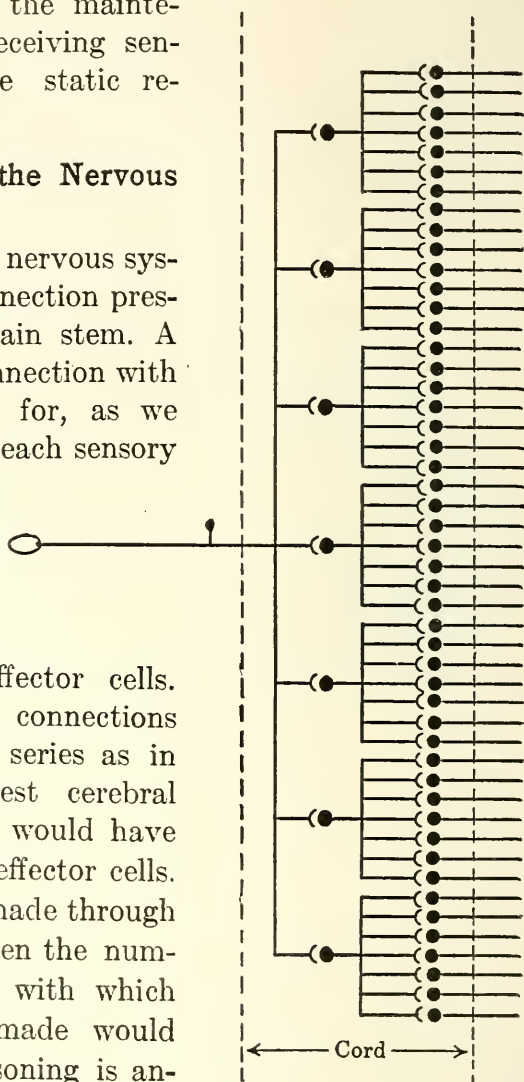


FIG. 19.—Showing how a sense cell is connected to many responding cells through three-neuron arcs.

THE FUNCTIONING OF THE NERVOUS SYSTEM

If this conclusion is true, the question immediately arises as to why every muscle does not contract and every gland secrete each time a stimulus is applied to a sense organ. It must be true that impulses do not traverse every possible route. The problem is to discover what determines the route to be followed. From the discussion of the preceding chapter, we are prepared to seek the answer in terms of gradient conditions and patterns.

A. The Functioning of the Cord and Brain Stem.

In the case of the earthworm we found a number of inter-connected segmental centers with gradient conditions of such a sort that the sense cells of any segment dominate most completely the muscles of their own segment. If the cerebrum of man and all neurons involved in connections with it were stripped away, there would remain forty-three inter-connected segmental centers. By analogy we might expect that the sense organs of any segment or level would dominate most completely the responding organs of its own level. In man's simplest and most ingrained behavior we find that this is true. Stimulation to the eyes causes contraction of the muscles in and about the eyes—blinking, turning toward and fixating the stimulating object, accommodating to distance, and adjusting for brightness. Stimulation to the ears leads to a turning of the head. Stimulation to the pain receptors causes a retraction of the part involved. The presence of food in the mouth leads to a flow of saliva and other digestive juices and to swallowing.

These segmental responses have short reaction times, are almost invariably released when their stimuli are applied, and remain relatively unmodified from birth to death. They are called reflexes, and no one questions that the lower nerve centers provide the connections responsible for them. Cerebral injury accentuates them, just as decerebration makes animal reflexes more pronounced.¹

¹ See Sherrington, *The Integrative Action of the Nervous System*.

In the case of the earthworm, we found also a head-tail or axial gradient. In man's reflex action there is less clear-cut evidence for a similar gradient. An indication of its existence is found in the raising of the infant's hand to its nose when the nose is pinched. In this case receptors dominate muscles posterior to themselves.

This part of man's nervous system seems to resemble that of the earthworm almost perfectly, not only in structure but also in functioning. If man had only his brain stem, cord, and nerves, he would be as autonomous, as invariable, as limited in his actions as the earthworm. But he has a cerebrum which is by far the largest proportion of his nervous system and which is placed superior to the rest of his neural equipment. An understanding of its functioning is our next concern.

B. The Functioning of the Cerebrum.

A body of evidence points to a gradual slope in rate of resting metabolism from the sense cells to the effectors. If this condition exists, the sensory areas of the cortex are higher in metabolism than the motor areas, and the association areas are intermediate in rate. To picture in a concrete way this set of conditions, let us suppose that these areas are arranged according to height on a funnel. The sensory terminations would be at the upper edge about the greatest circumference, the motor neurons at the base of the upper half with their axons extending down the spout, and the associative neurons would form the sides. Before considering the course of impulses through the cerebrum, let us consider the course of water down the funnel. When water is allowed to trickle from some point at the top of the funnel, its most natural course is straight down the side, but actually it may come to the spout at the side opposite from the one at which it started or at any other point. It may spread out so as to cover a considerable area or even divide into two streams. The factors that determine its course are numerous: wetness or oiliness of spots along the sides, irregularity in the surface, differences in the temperature of regions of the metal.

If the analogy is valid, we might expect that the excitation of a given sensory region may be propagated to any point within the motor area, to several adjacent points, or to various separated points. But even if this is so, we have not found what factors or conditions, corresponding to the oiliness of the funnel, determine just which course shall be taken. What they are, no one knows with any degree of exactness, but from many experiments made by Pavlov on cerebral functioning in dogs, from studies in gradient origin made by Child and his associates, and from numerous other related investigations two general statements seem warranted. (1) Impulses originating in a given sense organ will pass into the motor paths involved in the response to stimulation of another sense organ when the second sense organ is stimulated shortly after the first. This is known as *the principle of deflection or drainage*. One experiment, that of Uexhuell, may be cited as showing drainage in a clear-cut fashion. In an earthworm he isolated one muscle on either side. Direct stimulation to the nervous system anterior to these muscles was found to be followed by equal contraction in the two muscles; likewise stimulation posteriorly. He then severed the inter-segmental connection posterior to the muscle on the left side, so that stimulation posteriorly could cause contraction in only the muscle on the right, although stimulation anteriorly could cause contraction in both. He finally stimulated the head and tail regions simultaneously. Contraction took place only in the muscle on the right, showing that the impulses entering that side from the posterior stimulation had deflected the impulses from the anterior stimulation into that side also. (2) Impulses, in passing over a route, as determined by the conditions stated in (1), leave relatively permanent modifications of such a nature that impulses are subsequently more likely to follow the same route. This is known as *the principle of permanent modification*. It is obviously a special statement of the principle stated in the last chapter, that differences in rate of activity leave qualitative differences in cellular constitution.

Let us make these rules more concrete by citing the behavior phase of some of Pavlov's experiments. He finds that if a dog's taste bulbs are stimulated shortly after his ear has been stimulated by a bell, the ringing of the bell will after several repetitions of these conditions cause a salivary flow. The impulses from the ear pass into the motor paths leading to the salivary glands (principle of deflection), and in repeatedly passing from the ear to these motor paths, leave modifications of such a character that eventually they follow this route even though food is not given (principle of permanent modification).

As the organism develops, there are evolved special cerebral routes which are an expression of past stimulus-combinations. Impulses propagated over these routes may determine the deflection of other impulses, and in this manner modifications may be built up on the basis of existing ones.²

The cerebrum is the structure par excellence for recording the past and for making possible new ways of acting based upon past experience. It does not store up sensory impressions, but it does become so modified that sensory excitations lead to modified behavior. The essential requirements for this modification seem to be that impulses reach the cerebrum from two or more sense organs simultaneously or nearly simultaneously. The rôle played by these requirements in the learning process will be pointed out in Part Two.

We have now completed the task assigned to Part One. We have found, as best we can in the present state of knowledge and in the space permitted, the contribution to the understanding of behavior offered by a study of man's construction. We are able to accept in an intelligent way what we were asked to accept in Chapter 2, that man's manner of behaving is determined by his construction, as the behavior of an inanimate object is determined by its construction.

² If definite regions of the cerebrum are extirpated, as in Lashley's experiments, the principle of deflection tells us that impulses reaching the cerebrum still find their way into whatever motor paths are active and that in this manner new pathways may be built up, *i.e.* a habit which has been broken down by extirpation may be re-established.

QUESTIONS AND EXERCISES

1. Make a comparison between man's nervous system and an automatic telephone system. Find as many places as you can where the analogy does not hold.
2. What are the objections to considering the nervous system as a mass of reflex arcs?
3. When one says that the nervous system functions as a whole or unit, does one make an implication that all neurons are active in each response?
4. To illustrate the interdependence of stimulus-response systems, have a friend or laboratory partner act as subject and elicit his knee-jerk under several conditions. The jerk is evoked by striking the patellar tendon just below the knee cap. Try it while the subject is sitting passively reading, then while he is clenching his fists, and then just after a sudden loud noise has been produced. Does the ease with which the reflex is evoked and the length of the kick vary with different conditions? Map out a series of experiments for working out this problem more thoroughly.
5. Compare the time of the reflex knee-jerk and a kick made intentionally in response to a touch on the subject's body. Give as good an account as you can of what happens in the nervous system in both cases.
6. Read and criticize the article on phrenology in some encyclopedia.
7. Do animals capable of a greater variety of responses necessarily have more efficient sense organs than those with fewer response possibilities? Justify your answer.

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PART TWO

THE DEVELOPMENT OF BEHAVIOR

CHAPTER 6

THE APPROACH TO THE GENETIC STUDY OF BEHAVIOR

INTRODUCTION TO PART TWO

When discussing in Chapter 2 the nature of psychological explanation, we distinguished two supplementary ways of accounting for acts, one in terms of construction and the other in terms of past conditions. Our aim in the remainder of Part One was to present the outstanding characteristics of the construction of living organisms, particularly of man. We turn now somewhat abruptly to a consideration of the principles underlying behavior development. Our interest will now be centered in discovering the conditions essential to changes in behavior which occur from birth to adulthood. By finding these principles we shall be enabled to account for a person's actions in terms of his past. In seeking these genetic principles, we should not lose sight of the conception previously evolved that development in behavior is made possible only through development in structure. The past influences behavior only as it has modified structure. Yet one can observe relations between past and present stimulating conditions and behavior while ignorant of the internal features of construction. Without knowing anything of the nervous system, we can observe that a pin prick is followed by retraction of the part pricked. Without knowing anything of the structural modifications involved we can study the conditions that precede the development of a distaste for a certain food. Although the complete explanation of behavior involves both a structural and a genetic account, the materials utilized in giving either type of explanation may be secured by studies in which the other type is practically ignored.

It is because of this independence that some persons who have given close attention to behavior are good "practical" psychologists although they know little or nothing of the nervous system. In this genetic study of behavior the "practical" and the "pure" psychologists meet on common ground. Both hold that if a child has been spoiled, there must have been something to spoil him, that if another is unselfish, there must have been conditions which gave rise to this trait, that if a third has a bad temper, there must have been a source—that any act or trait has its history or cause. If they believe this, it is a logical necessity to hold also that the direction of development could be controlled if all causes were known. If, then, one is interested in the formation of good habits and eradication of undesirable ones, it is to the section of psychology which deals with habit formation that one will turn.

The pure psychologist has the advantage over the practical one in that he can take his problems to the laboratory, break them up into smaller ones, control with greater accuracy the stimulating conditions, make observations on a larger number of individuals, and utilize instruments and techniques for obtaining a more careful and exact record. Under these conditions the possibility of finding more fundamental principles is greater. Yet it is to be emphasized that in his search for basic principles he keeps a practical reference. His aim is to understand that behavior which is socially most significant, *i.e.* to accumulate that information which has greatest practical import.

In Part Two we shall be interested first of all in presenting the results of laboratory studies of behavior development, and then, having found the set of principles indicated by these studies, we shall be concerned with showing how well they account for and make intelligible such developments in behavior as are evidenced by man. Since each experience which a person undergoes leaves a more or less pronounced trace, obviously all that can be done is to single out the more significant and typical sorts of developments and give an account of them.

In approaching these problems, it would seem well in the interests of clarity to lay down a set of definitions which will serve as a scheme for classifying and describing behavior and another set which will enable us to see more clearly what is done when one element of behavior or one component of the environment is singled out and assigned a definite significance.

CLASSIFICATION OF RESPONSES

A response may be placed in one of two groups *on the basis of its history*. It may be either learned or unlearned. An *unlearned response* is one made when the eliciting stimulus or one similar to it has not necessarily occurred previously in the individual's experience, while a *learned one* is a response which does not occur unless the eliciting stimulus or one similar has been previously encountered. This distinction will be brought out more fully as we proceed. For the present, it may be illustrated from the studies of Pavlov. When food is placed in the dog's mouth for the first time, a secretion of saliva results. No training, no practice, no previous experience with food is required. The response is unlearned or unconditioned by past experience. After definite training of the dog a bell also elicits the flow of saliva. This response requires a previous exposure to the stimulation from the bell; it is learned or conditioned upon past experiences.

Another way of classifying responses is *on the basis of the responding organs involved*. A response may be said to be skeletal, visceral, or verbal. (1) *Skeletal responses* are those involving contraction of the muscles attached to the skeleton. The contraction may be great enough to produce movement of the attached skeletal part, in which case the response may be spoken of as *overt* or *explicit*. In other cases the contraction may produce only a tension of the tendons and thus a greater readiness or preparedness for overt action, just as the pull of a horse upon a heavy load may not be sufficient to move it but will serve to make the load more readily moved by additional pull. These skeletal responses may be termed *implicit* or *covert*, or simply tensions. (2) *Visceral responses* are stimulus-induced

activities in the smooth muscles and glands as, *e.g.* the secretion of saliva and other digestive juices in response to food in the mouth, or the wave of contraction in the smooth muscles of the esophagus. (3) *Verbal responses* are those which result in sounds or symbols used in language, which in a sense are substitutes for skeletal responses, or tensions in the muscles used in producing the sounds or symbols. Those which result in sounds may be termed *vocal* or *overt*, while tensions of the muscles used in producing sounds may be termed *sub-vocal* or *implicit*.

On the basis of their complexity reactions may be divided into four groups: simple, serial, pattern, and orientation responses. *Simple responses* are those which can be described by the use of one word in addition to the words used in designating the part moved, *e.g.* withdrawing the hand, blinking the eyes, closing the hand, lifting the foot. *Serial responses* are those in which two or more simply described actions follow each other in a regular sequence, *e.g.* the succession of responses in suckling, the formation of one sound after another in talking. *Pattern responses* are those in which a number of simple movements occur simultaneously, *e.g.* those involved in throwing a ball or those included in the fear reaction of infants. *Orientation responses* are those in which the organism or some part turns toward or maintains a position toward some stimulation, *e.g.* turning toward a sound or keeping the eyes fixed upon a light. Turning involves an unequal contraction in bilaterally similar muscles, and maintenance of position involves equal tension in these pairs.

Responses may be grouped in still another way, *on the basis of the result to which they contribute*. Many acts contribute to the procuring of food and may be designated as food-getting activities. The separate acts may be quite dissimilar, and any one of them may be simple or complex. They are placed in a group only because of the consequence which is dependent upon them. This sort of classification inclines one to think that there must be a cause common to all the acts included. These sup-

posed causes are often termed instincts, *e.g.* the food-getting instinct which is presumably responsible for food-getting activities. This is much like saying that there is a falling or ground-hitting instinct possessed by raindrops. As previously pointed out, we must be on our guard against the tendency to use names convenient to description for explanatory purposes. It is legitimate to group acts on the basis of their consequences, but knowledge of the consequences does not help to explain the acts. In Part Three more will be said with reference to the concept of instincts. Let us, in order to avoid the many connotations of the term, speak of a group of acts all of which contribute to one result as a *concatenation of reponses*.

THE CONCEPT OF STIMULUS AND RESPONSE

We have just pointed out one of the dangers resulting from classification. Another is the danger of considering a response as simple as its description and as simply caused as the account would seem to indicate. We speak of responding to a call for dinner. The activities included in the response are complex and varied. Moreover, many factors (in addition to the mere call) enter into the determination of that response. The fact is that we are continuously subjected to a multiplicity of stimuli and are continuously displaying a complexity of activities. If this be the case, one wonders how it is that we may ever speak of a stimulus and its response. Before taking up this question, let us in the interests of clarity note certain definitions already made and add others.

(1) Man's environment is all that is external to his sense organs, whether those organs be on the surface or imbedded within the body.

(a) A *situation* is the environment at a definite time.

(b) A *stimulus* is the smallest change from one situation to another that will be followed by change within the organism, *e.g.* light waves of one length or sound waves of one frequency.

- (c) An *object* is a relatively stable spatial configuration of stimuli which have been given a name or short description, *e.g.* a table, a newspaper.
 - (d) An *occurrence* is a temporal set of stimuli which arise from an object when it is acted upon by some force from its environment and which have received a name or short description, *e.g.* the ringing of a telephone, raising the arm.
 - (e) An *event* is a series of related occurrences, *i.e.* occurrences which are commonly observed together, their order being independent of the nature of the individual's responses, *e.g.* a football game, a show.
 - (f) An *excitant* or *stimulation* (or stimulus in a loose sense) is the appearance in or disappearance from the individual's immediate environment of a stimulus, an object, an occurrence, or any combination of these.
- (2) Human behavior is the totality of changes going on within the organism.
- (a) A *response* is the change in behavior—excitation in sense organs, propagation of neural impulses, contraction in muscles together with the movement of the attached parts, and secretion from glands—which follows an excitant.
 - (b) A *reaction* or *adjustive behavior* is that part of a response which directly affects the environment, particularly other individuals, *e.g.* moving an object which not only affects the object but also changes the pattern of light reflected to another person, speaking a word which sets up vibrations in the air and thereby becomes an excitant for someone else.
 - (c) An *act* is a series of related reactions, the order being effected by changes in the environment (external, or internal, or both) arising as each reaction takes place, *e.g.* opening a door, writing a letter.

With these definitions before us, we may more clearly answer the question raised above. Although behavior is the result of the total stimulation rather than of discrete parts of the situation, yet a response may be referred to a special part when it occurs regularly in the presence of that component of the situation and fails to take place in its absence. The mere presence of food may not elicit a flow of saliva, as in fact will be the case when some other highly effective stimulus is active, but if food is the only element common to a number of differing situations and if saliva flows in each case, the flow of saliva may be referred to the presence of food. It is to be held responsible for the flow rather than the total situation or any other component of it. For similar reasons one element of activity may be considered in relative isolation from others. True enough, no movement occurs in isolation from others; but when it occurs as an element in differing sets of activities, it may well be considered as separable from the other activities. Even when a response occurs regularly as one of a group, it may for purposes of study and measurement be singled out with the assumption that it serves as an adequate indicator of the whole group. Pavlov ignores the other activities accompanying the flow of saliva and studies it not only because of the ease with which it can be measured but also because the accompanying activities are largely irrelevant to his problem. To break a problem up into simpler ones is a common procedure in all branches of science, but one must be on his guard against considering the simple problem the whole. As long as it is recognized that the conceptions of stimulus and response are convenient to study, but not full descriptions of stimulation and resulting activity, we may employ them.

QUESTIONS AND EXERCISES

1. Give an example of each class of response given in this chapter.
2. One often reads or speaks of mental responses. Why, do you think, were mental responses not given as one class? Do those responses usually designated as mental fall into any of the classes given in the text? Do responses usually termed mental have a common characteristic?

3. When we move a chair rather than sit in it, are we responding merely to the chair? If not, what determines our response? Does your answer have any significance with reference to the problem of choice?

4. When we say that we see a blackboard, to what are we responding? The blackboard does not reflect any ether waves.

5. How many muscles are involved in fully extending the arm while standing? Why do we not always call attention to all muscles involved in an action? Similarly why do we not speak of the earth's falling toward a piece of chalk?

CHAPTER 7

UNLEARNED BEHAVIOR

When a new way of responding is developed, a new response is not created, but one that has already been exhibited comes to be released by stimulating conditions which originally failed to release it. When the conditioned salivary flow is developed, there is no addition to the dog's repertoire of reactions. The change lies in the fact that the flow of saliva comes to be elicited by the ringing of a bell. Learning is a modification and augmentation of the stimulus-response relations. The first learned reactions are built upon unlearned ones. In consequence, the first problem confronting one interested in the genetic history of behavior is to find what responses are included in the unlearned repertoire. This problem will be the concern of the present chapter.

The psychologist's interest, we have held, is centered in adjustive responses. Since few of these are exhibited during the embryonic period, he may justifiably begin his historical account of behavior with the activity displayed at birth. In the foetal stage the organism is comparatively passive, the influence of the environment being largely confined to the furtherance of growth, while after birth the individual becomes increasingly more active, capable of displaying a progressively greater variety of responses. Environmental stimulation after birth leads him to react upon his surroundings and to modify them. This change in the form of behavior is attributable to the fact that growth is alteration in construction, and modification in structure means modification in behavior.

THE CHARACTERISTICS OF UNLEARNED RESPONSES

At birth each person is a well-developed structure fitted to survive in his new surroundings. When he makes a response to

some stimulation that is novel for him, we designate that response as unlearned. When for the first time he is surrounded by air, a birth cry is released and breathing is initiated. It has not been necessary to learn how to cry or to breathe. In the same manner many other activities are brought about by novel stimulating conditions. *The essential criterion for distinguishing an unlearned response is that the stimulus which calls it forth need not have occurred previously.*

There is one seeming exception to this rule. Some stimuli which are in a sense new will be effective upon their first presentation but only after similar stimuli have been encountered. In these cases the response is conditioned by past experience or learned. For example, the flow of saliva is an unlearned response to food but not to a bell or buzzer. If a bell is rung simultaneously with the giving of food, the bell will become potent for producing the flow of saliva, and a buzzer will also become effective even though it has never been sounded in connection with food. We must modify our rule to read: *Unlearned responses are those made when the eliciting stimulus or one similar to it has not necessarily occurred previously.*

It is apparent that responses made at birth are unlearned, and a little study reveals the fact that many unlearned responses appear later. If a baby at two months blinks its eyes in response to a rapidly approaching object regardless of whether this stimulation has previously occurred, the blinking must be considered unlearned. If a bird when twenty days old flies without practice, the flying must be classed as unlearned.

Those responses which are clearly shown to be unlearned by the application of this criterion have three secondary characteristics which further differentiate them from learned reactions. (1) The time elapsing between the presentation of the stimulus and the appearance of the reaction is comparatively short, from .03 to .15 second. (2) These responses are also relatively unmodifiable, *i.e.* after their appearance they tend to continue as a part of the organism's reaction repertoire throughout the remainder of its life. (3) Further they are relatively invariable,

are almost certain to be released whenever their stimuli are encountered, no matter what the environmental situation. The knee-jerk, blinking, and sneezing are examples of responses possessing these three characteristics. When any reaction exhibits these distinguishing traits, there is good reason to believe that it is unlearned even though the fundamental test fails to apply. For example, in most infants blinking does not occur the first time an object is moved rapidly toward the eyes; nevertheless it is considered unlearned. Blinking in response to this type of stimulation first appears when the baby is from fifty-five to one hundred and twenty-five days old and subsequently is marked by rapidity, unmodifiability, and invariability. Its possession of these traits together with the fact that it appears in three-month-old infants who up to this age have not been stimulated by rapidly approaching objects leads psychologists to consider the response unlearned in all.

Another less reliable criterion is universality. Unlearned responses are included in the repertoire of practically all persons, and so when any response is possessed universally, there are some grounds for considering it unlearned. Of course, the universality of an act may be due to the universality of conditions conducive to its acquisition. It may be a common habit. All people shade their eyes with their hands when looking toward the sun. This act does not possess the characteristics given in the previous paragraph; it is gained from experience and is performed deliberately.

THE ORIGIN OF UNLEARNED RESPONSES

One marvels at the fact that during the embryonic period a construction of such a type develops that the organism is enabled to survive in its new surroundings. One is inclined to believe that the formations involved in post-birth behavior have been created to meet post-birth situations, but with Part One as a background we cannot yield to this temptation. We must consider, rather, that the structures, as we find them at birth, have evolved in the manner described in Chapter 4

as the resultant of the nature of the germ plasm and the environments in which this and its successive modifications exist. The development is not a matter of heredity alone; it is not an unfolding of potentialities independent of environmental conditions, nor is it made with foresight although it is of such a character as to make for survival. Normal birth structure is the result of normal germ plasm developing in a normal environment, and an abnormal birth construction results if either the germ plasm or the uterine environment is abnormal. Human infants have been born with a single eye in the center of the head, and it is reasonable to suppose that this was due to environmental conditions similar to those which under experimental control cause a fish to develop a single eye. Infants have been born with two thumbs on one hand, and again it is logical to assume that this is due to environmental conditions similar to those which cause a frog to develop several legs. That infants are as highly similar as they are, means that their embryonic environments are much alike just as truly as it means that the fertilized ovums from which they started resemble each other. Hence, birth construction and the responses of which it is capable should not be spoken of as inherited.

The somewhat striking fact about uterine development is that structures and sets of structures develop in one type of surroundings and are prepared to be thrown into typical and adjustive action by another set of conditions encountered later. The muscles, the muscle attachments, and the neural connections involved in breathing are formed in the absence of air. The eyes as well as their neural connections mature in the absence of light. The taste bulbs grow in the absence of the stimulations which in post-birth days excite them. The digestive apparatus develops in the absence of foods to be digested. The muscles and skeleton originate under conditions where rigidity and movement are not demanded. This growth which takes place under one set of conditions and which results in structures capable of reacting to other conditions is the basis for unlearned responses. Physiological investigation has re-

vealed many of the germinal and environmental features requisite to the growth of these structures, and research continues in the hope of discovering others. It has been found, for example, that axons grow in a direction determined by the electrical field in which the neuron exists and that electrical fields arise from differences in the rates of metabolism. Again, it has been discovered that an eye develops only when nervous tissue and skin tissue come into proximity with each other.

As we have already noted, growth does not cease at birth. The cells of the various organs of the body are bathed in the blood lymph which carries to them materials to be used in their synthesis and away from them substances which have been broken down in their activity. Each organ as well as each cell has always for its immediate environment other organs and cells, and the conditions imposed by these interrelationships already formed at birth give direction to post-birth development. As long as food, air, and water are present and the mechanisms for taking them directly or in modified form into the blood stream are operative, there will be growth or maturation intra-organismically determined, *i.e.* determined relatively independently of other factors of the external environment. This growth results in the development of structural mechanisms capable of being thrown into action by external stimulations, *i.e.* lays the basis for those unlearned responses which do not appear at birth but which are exhibited later.

INVENTORY OF UNLEARNED RESPONSES

From the discussion of the characteristics of unlearned responses and the development of the structures involved in their execution, we shall now turn to an inventory and description of those possessed by man. We shall group them on the basis of their complexity.

A. Reflexes.

Practically all, if not all, vegetative activities, *i.e.* those concerned with the intake of food, water, and oxygen, with the excretion of faeces, urine, perspiration, and carbon dioxide, with

digestion, and with circulation are unlearned. Involved in these activities are chemical processes, the breaking up of food by digestive juices, absorption, osmosis, endosmosis. There are also numerous reflexive responses. Food in the mouth releases the flow of saliva, in the back of the mouth it initiates swallowing, and in the stomach it starts the flow of gastric juices and the peristaltic movements of the stomach. Conditions in the bowels set up bowel movements, those in the bladder give rise to urination, excessive heat causes perspiration, variations in hydrogen-ion concentration control breathing, pressure in the auricles and ventricles leads to heart action. In a like manner the many other vegetative activities have stimulating conditions which without learning give rise to simple, rapid reflexive action.¹

In all probability the basic postural and locomotor actions are also provided for by reflexive mechanisms although the direction of locomotion and the posture taken by adults are conditioned by experience. The sensory paths from the static receptors go to the cerebellum, whose function when traced phylogenetically is shown to be reflexive in nature. Most of the higher animals are able to stand and walk at birth. The human structure is not sufficiently developed at birth to provide these abilities, but it has been found that babies who were kept in a reclining position until four or five months old were able to sit erect without practice. In a few cases in which long clothing was intentionally used to prevent the baby from standing, he stood as soon as sufficient freedom was allowed. In fact, these infants not only stood erect but also walked successfully at once, lending evidence to the view that walking, too, is unlearned. Spaulding has shown that if birds are bound so they cannot move their wings, they will fly at once when the binding is removed provided they are as old as their mates who fly. It would, of course, be precarious to hold that, because birds can fly and animals can walk without learning, man's ability to walk

¹ Practically all these reflexes may through the process of simple conditioning (to be discussed in the next chapter) come to be released by other stimuli, *e.g.* the odors arising from food come to cause the flow of saliva.

is also unlearned, but these analogies, when considered with the few cases in which walking has been observed to occur without practice, seem to justify the conclusion. The probabilities favor the opinion that holding the head erect, sitting, standing, and walking are unlearned.

The receptors involved in the reflexes which we have just mentioned are located internally. The responses are not directly involved in the adjustment to the external environment but rather form the foundation for adjustive reactions. Those of the first group, the vegetative responses, are concerned with nutrition and growth, processes which are formative rather than adjustive. Those of the second group, the postural tensions, create a base upon which movements of the arms, head, and trunk take place, while locomotion makes approach and retreat possible, but the postural and locomotor responses are not adjustive *per se*. Locomotion to be adaptive must have proper direction with regard to external conditions. Consider from the standpoint of adjustment the contrast between movement of itself and movement from the path of an approaching automobile.

In addition to these two groups are many unlearned responses made to stimulation of the exteroceptors. The majority of these are adjustive. Excitation of pain receptors elicits retraction of the part stimulated or in some cases causes a limb to be moved to the region. If a baby's nose is pinched, the hand is moved to the nose; or if the knee is pricked, the foot of the opposite leg is raised to the pricked knee. The head is turned when the nasal passage is held closed. If the cheek is touched an hour or more after feeding, the head is turned in such a way that the lips are brought to the object, and they are protruded so as to encircle it. Other reflexes in this group are the pupillary, the blinking, the clasping, the patellar, and the Babinsky. The pupillary reflex is the automatic adjustment of the size of the pupil to suit general illumination. The patellar reflex is the familiar knee-jerk elicited by a blow delivered just below the knee cap. The clasping reflex, elicited when a rod touches the

palm of the infant's hand, is sufficiently energetic to support the infant's weight. The Babinsky reflex is a spreading and flexing of the toes in response to light pressure applied to the sole of the foot. These last two reflexes disappear at an early age.

B. Orientation Responses.

An infant fixates a bright object with its eyes, and when the object is moved, he follows the movement by turning the head as well as the eyes. The eyes are turned right and left by the internal and the external rectii. Light coming from an object to the right of the line of vision falls upon the left half of the retina, and if the eye is to be turned toward the light, this excitation must give rise to neural impulses delivered in the muscles attached to the right of the eyeball. In other words orientation of the eyes is exactly analogous to the orientation or tropistic reaction of the mythical beast. Infants at an early age also orient to sounds. A sound coming from the right strikes the right ear with greater intensity than it does the left ear, and on the basis of this intensity difference we are enabled to turn toward it. As adults we cannot distinguish whether a sound comes from directly back of us, from straight in front, or from directly overhead, since in all these positions the intensity to the two ears is equal.

C. Pattern Responses.

When an infant's activities are observed with a view to discovering whether or not certain responses regularly occur in combination, only two patterns are revealed, as cited by Watson.² A loud noise or a sudden jarring causes catching of the breath, clutching with the hands, closing of the eyelids, and puckering of the lips, followed by a whimpering cry. These skeletal reactions are accompanied by profound visceral changes which will be specified later. The combined skeletal and visceral activities may be called fear, or the induced visceral state may be said to be the emotion, and the skeletal response to be its

² *Psychology*, pages 199 and 200.

expression or accompaniment. The author, for reasons which will appear later, prefers the latter definition.

The second pattern appears when the infant's movements are hampered. The visceral disturbance is anger and the skeletal accompaniments are a stiffening of the body, kicking, fairly well-coördinated striking and slashing movements of the arms, and crying or screaming.

D. Serial Responses.

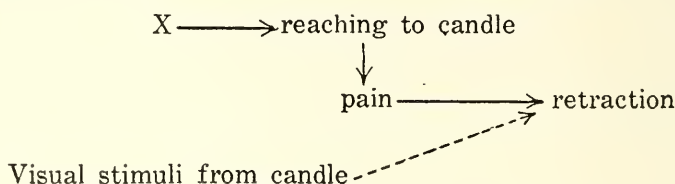
Suckling is the one seriated act of which the infant is capable. When a baby is hungry, a touch on the cheek elicits a turning of the head. This brings the lips to the nipple, and they are protruded so as to encircle it. The new pattern of stimulation leads to expansion of the chest and action of the cheek muscles and tongue. The milk which enters the mouth causes swallowing and other responses involved in digestion. The elements of this sequence are reflexes evokable individually. Normally each brings about the stimulation for the next so that they regularly occur in a definite order. Many human infants do not suckle readily at the first opportunity, but the fact that many do suckle at once and the fact that in other mammals the act is clearly unlearned seem to justify its inclusion in the list of unlearned accomplishments.

E. Random Activities or Anomolous Reflexes.

A large part of the contented baby's behavior consists in cooing, gurgling, kicking, wriggling, and moving its arms. There is no particular stimulation to which any one response may be referred, although, to be sure, each movement is the result of internal and external conditions, just as the shooting of the flame of a log fire first here and then there is the result of the totality of conditions in and about the burning wood. There is acting upon the infant at all times a multiplicity of stimuli, no one of which dominates behavior for any length of time, or perhaps more correctly no one of which alone dominates behavior for even a short time. As the pattern of stimulation changes, so the pattern of response varies, making it impossible except in a

few cases to observe a relation between any one part of behavior and any part of the total stimulating conditions. The various movements made under these conditions are most aptly termed random movements since they occur in unpredictable combinations and sequences. When one is singled out for notice, its stimulus must be written as X (unknown), and it might well be termed an anomalous reflex.

These random activities serve to bring new stimulating conditions to bear upon the infant and make possible the establishment of ways of responding in line with experience. For example, if a baby in its random activity reaches to a lighted candle, pain stimulation is encountered. After a few experiences the infant will avoid the candle. The following diagram in which



the dotted line indicates the new stimulus-response relation suggests the rôle played by anomalous reflexes.

MAN'S UNLEARNED RESPONSES COMPARED WITH THOSE OF LOWER ANIMALS

The number of man's unlearned responses is small indeed when compared with the repertoire of learned acts which he gradually acquires. The list also presents a striking contrast to the unlearned activities exhibited by lower animals. A consideration of the complexity of unlearned activities which some animals display may serve to raise the question of whether our inventory is complete, or whether man's unlearned equipment provides for greater diversity in behavior than we have indicated.

In Chapter 4 we noted that the ladder type of nervous system is characteristic of worms, crustaceans, insects, and spiders. It is generally conceded that these animals display little learned

behavior in their normal activity, yet their reactions are complex, varied, and conducive to the preservation of the individual and the species. Flies lay their eggs in decaying material which provides food for the young. One is inclined to believe that this action shows foresight, reasoning, or intelligence, but careful study reveals that it is a chemo-tropism, *i.e.* a reaction reflexly evoked by the odor emanating from the material. A board covered with asafetida serves to release the same reaction as decaying material. Several species of wasps paralyze their prey, and in this state it is preserved until the young wasps are hatched. A wasp, of the species French *Sphex* or *S. ichneumonidea*, takes its victim to its hole, drops it, returns, and with it backs into the nest. This sequence is unalterable. In studying this wasp, Fabre repeatedly removed the prey after it had been deposited at the entrance of the hole, and the wasp after searching and rediscovering it always dropped it beside the hole. Bees and ants have a complex group organization in which each insect performs a set of tasks according to its structural nature, according to whether it is a queen, a drone, a worker. Each act is determined by the construction of the insect and the immediate situation. There is no necessity of postulating foresight. Spiders spin complicated webs after the fashion of their kind, lie in wait for their prey, pounce upon it, and bind it. Several beetles and flies build trap doors at the entrances to their homes. We might add instance after instance of unique and complicated achievements made possible by a construction practically unmodified by individual experience.

There are five classes of vertebrates—the fishes, amphibians, reptiles, birds, and mammals; and only in the higher mammals is any marked amount of learned behavior evidenced. Birds attain the greatest complexity in behavior achieved without a significant amount of learning. Neurologically they possess a much greater development of cerebellum than animals below them in the phylogenetic scale, but their cerebral cortex is little more developed than that of the amphibians in which it first makes its appearance. Birds represent the peak of develop-

ment of reflex centers but are markedly deficient in integrative ones. They are the best subjects of study if one is interested in unlearned behavior.

When studying organisms capable of the variety of activities displayed by birds, it is convenient to have some scheme for grouping responses. A classification based upon the consequences to which the activities contribute seems to be the most useful manner of grouping. On this basis Watson makes the following divisions.³

- | | |
|---|--|
| I. Structural characteristics, action systems, etc. | { Bodily characteristics by means of which species are determined; methods of locomotion, such as creeping, crawling, walking, etc. |
| II. Obtaining food. | { Taking food from beak of parent; sucking, pecking, scratching, diving; selection of food (when not determined by habit), <i>e.g.</i> herbivorous, carnivorous, etc.; the use of salt instead of fresh water; washing the food; methods of drinking, etc. |
| III. Shelter. | { Stretching the wing to escape the sun; sunning, huddling, ruffling the feathers when cold, etc.; burrowing, taking up abode in hollow logs and trees; boring into timbers; hibernation, etc. Overlaps to some extent the group on sex and food. |
| IV. Rest, sleep, play, etc. | { Night and day periods of activity, purely instinctive, since no structural peculiarities account for the differences; length of periods at nest, brooding or caring for young; habits of sleep, <i>i.e.</i> bodily attitudes chosen; play; hibernation, etc. |
| V. Sex. | { Mating; copulation; nest site; material of nest; methods of building nest; number of eggs laid or young cast; length of mating period or period in which partnership endures; care of the young, etc. |

³ *Behavior, an Introduction to Comparative Psychology*, pages 112-113.

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|---|--|
| VI. Defence and attack. | { Methods of attack, as lying on back; springing upward (to head and throat); spurring, goring with the antlers or horns, etc. Here belong also the hunting, stalking, seizing, and rending of live prey; shamming death; inflation of body; ejecting secretions, etc. |
| VII. Special forms of instinct. | { Migration (possibly homing in general) as exhibited by birds, mammals, fish, reptiles. Possibly overlaps sex and food, but may be wholly independent of either. Mimicry. |
| VIII. Vocalization. | { Calls, cries, sounds uttered in receiving food; during sex activity, etc. Shown in almost all vertebrate forms, but especially in the monkeys of the higher types and in birds. |
| IX. Unclassified and non-adaptive but complete acts. | { Strutting, dancing, inflation of cheek pouches; secretion of musk; elaborate nodding (as in noddy tern). |
| X. Unclassified and non-adaptive, in this case random and abortive. | |
| XI. Individual peculiarities in response. | { Reference is made here to very definite phenomena but ones hard to describe, such as persistence or the reverse in an attack on a problem; boldness; individual tricks of the hands, beak; ambidexterity or preponderating use of either right or left hand by an animal below man; probably hereditary but not known to be. |

The acts listed as illustrative of each group are almost purely unlearned in birds and the lower mammals. The responses are exhibited by each member of the species regardless of how it is reared as long as it has a normal embryonic environment and is provided with the proper materials for nutrition.

Each species has a characteristic set of activities involved in

nesting and feeding. To the ornithologist the features of a nest reveal the species of the bird that built it. In some species the female sits on the nest and is fed by the male, in some the reverse procedure is followed, in others the male and the female perform the task alternately, while in still others the male gives no help in nesting or in rearing the young. The fledglings secure their food in a manner peculiar to each species. Some open their mouths to receive the food from the parents, others take it from the parents' beaks, and still others peck it from the ground. These nesting and feeding procedures are followed as steadfastly by birds reared in isolation as by those raised under normal conditions.

Each of us has observed some interesting peculiarity of birds. It may have been the darting of mud swallows, the lightning-like drop of a hawk upon its prey, the flutter of a turtle dove as she is frightened from her nest, the plunge of the kingfisher, or the rush for water by ducks even though they have been reared by a mother chicken. The connoisseur of birds can distinguish the species by the manner of flight. The flitting of warblers, the cycloid soaring of hawks, the shambling flight of owls, the graceful sweeps of the large woodpeckers are characteristic.

The songs distinctive of each species are developed by birds raised in isolation. Scott and Conradi have noted this for many species. They find, however, that if a bird is reared where it hears only the song of another species, it tends to imitate this song rather than to develop its own. A canary which they reared with sparrows chirped like the sparrows, while a sparrow raised with canaries was able to approximate their song. A blackbird reared where it heard the crowing of roosters developed a cry much like that of a young rooster. The mocking bird is capable of incorporating into its song repertoire most sounds that it hears. When hatched near a barnyard, it learns to whistle in imitation of the farmer's call for horses and dogs.

These modifications in the vocalizations of birds show that there is some modification by environment. Perhaps there is

more learning in other sorts of activities than is usually conceded. To rear an animal in isolation does not deprive it of all possibilities of learning, only of the opportunity to learn from others. An example of a response which was once thought to be unlearned and is now considered learned is the chick's act of following the mother hen. Without practice the chick follows any moving object. Normally the moving object is the hen, and soon the chick learns to follow her exclusively. Cases are, however, not uncommon in which the moving object is a person, a cat, or a dog, and in time these are followed in preference to a hen. *Repeated stimulation by a particular stimulus makes it increasingly effective and makes others less and less effective.* A good illustration is found in Stefansson's observations of the behavior of his dogs when offered a diet to which they were unaccustomed. The customary rations were seal, caribou, and fish. On one occasion only geese were available, and considerable time elapsed before the dogs would eat them. At another time when a wolf had been killed and was offered them, all refused to eat it. Stefansson sought to ascertain how long this abstention would continue. For three days the dogs did not eat and then they began to eat in the order of their ages, the youngest first. The oldest went without food for two weeks and was finally given his regular diet to prevent starvation.

Not only does environment show its effects in an increased potency of stimuli which had an original effectiveness, but it also shows its influence in giving an effectiveness to stimuli which originally had none. As we have just noted, the movements of the mother hen cause approach from the beginning. If she clucks just before or as the chicks approach, her clucking comes to cause approach. *An ineffective stimulus paired with an effective one gains a cogency for eliciting the response originally belonging to the effective stimulus.* The chick learns to obey the mother's cluck but does not instinctively heed it.

The modifications produced by environment in invertebrates and the lower vertebrates cannot, however, be extensive because

when they are taken into the laboratory to test their ability to learn, this ability is found to be quite meagre. An earthworm may be taught by being given more than seven hundred trials to pass through one arm of a Y-tube rather than the other. Triplett taught two perch to refrain from darting toward minnows. For thirty minutes a day minnows were placed in an aquarium with the perch but separated from them by a glass partition. At the end of a month the perch no longer took notice of the minnows. Thorndike succeeded in accumulating some evidence of the learning of a maze or labyrinth by fish. Partitions with openings were arranged between a sunny area and a shaded one in the aquarium. When the fish were placed in the sunny region, they started swimming toward the shaded one. When they encountered a partition, they swam about with their noses against it and finally found the opening. With repeated trials they learned with some degree of accuracy the location of the opening. Yerkes taught a turtle to reach a nesting place through a maze with a few blind alleys. After fifty trials the turtle had reached the stage in which it made few mistakes, *i.e.* few entrances into blind alleys. Several species of birds have been taught to find their way out of simple mazes. In all these studies learning is sufficiently slow to make us feel certain that it cannot play a great part in the normal activities of the animals. It is only in the higher mammals—dogs, cats, monkeys, apes, and man—that learning assumes a great importance.

This brief review of the rôle of unlearned behavior in lower animals suggests that a great deal of adult human action may be due to maturation rather than to true learning. Man's reflexive centers are as highly developed as are those of any lower animals, and we might expect to find as great a complexity in his unlearned activities as is found in the lower animals. But such a large part of man's behavior is influenced by social contacts, so much diversity in the activities carried on by different men is in evidence, and so many acts are conditioned by past experience that there seems little justification for ex-

tending our list of unlearned activities. It is true, as we shall see more fully later, that all learned responses are built upon or are modifications of unlearned ones, that there is no creation of responses through learning. Hence the unlearned possessions of man must be great, but they are exhibited not as definite responses to definite stimulations but rather as random activities. Man has in his random repertoire a greater variety of unlearned responses than any lower animal, but he does not possess so great a variety of definitely adjustive responses. If his random activities are to contribute to his adjustment, they must cease to be random, and they do this as learning progresses. It seems to the author that the outstanding characteristic of man provided by his original nature is his continuous and varied activity. Even though in infancy his responses are for the most part random, they are rich in variety and lead him into new stimulus-combinations which afford the groundwork for learning. A situation calls out no predetermined response but rather a variety of acts of which one is more appropriate than others. Subsequently this act is released in similar situations and becomes a habit. From random activities responses appropriate to the situations of life are established, but the resulting habits tend in turn to fixate behavior at a given level and leave him equipped only for the environment in which the habits have been developed, to make him as restricted and as mechanical as the animals which adjust originally by definite responses. Whatever the truth of this conception, whatever the number and extent of man's unlearned responses, it is certain that his behavior cannot be understood apart from a knowledge of how he learns. Consequently we shall turn to a search for the principles of learning.

SUMMARY

An unlearned response is one displayed when the eliciting stimulus or one similar to it has not necessarily occurred previously. The structures—sensory, neural, and motor—involved develop in one type of surroundings and are prepared to be

thrown into typical and adjustive action by another set of conditions encountered later.

Man's vegetative, postural, and locomotor activities, those elicited by proprioceptive stimulation, are unlearned. There are also a number of simple responses to exteroceptive stimulation displayed without the prerequisite of practice. In addition are the multitudinous random activities from which adjustive habits are developed.

QUESTIONS AND EXERCISES

1. Discuss in detail the relation between Chapter 4 and the topic, the origin of unlearned responses.
2. With some friend or a laboratory partner acting as subject evoke his patellar, pupillary, and blinking reflexes. Test their modifiability.
3. Give a full definition of random activities.
4. Could an animal as efficient as man be developed through an increase in the number and size of reflex centers, *i.e.* through an increase in the number and variety of unlearned responses? If not, why not?
5. When we group a number of acts because each contributes to a common result, why do we tend to explain the acts by the group name?
6. Must all responses be adjustive? Can you think of unlearned human responses which are non-adjustive?

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CHAPTER 8

LEARNING IN ANIMALS

Man's behavior contrasts in many ways with that of lower animals, one of the outstanding differences being in the amount of learned behavior displayed. This does not mean that man learns in a way unlike that of animals. In fact many of his activities are without doubt acquired in essentially the same manner as habits are taken on by animals. Since this is true and since animals may more readily be studied experimentally, psychologists have turned to them in their attempt to discover the basic principles involved in learning. After searching out these principles, as they are revealed in animal investigations, we shall turn to a consideration of their applicability to human acquisitions.

THE CONDITIONED RESPONSE

It is generally conceded that the simplest sort of learning exhibited by animals is that in which a response comes to be evoked by a stimulus which was originally ineffective in eliciting it. This type of change in response has been the object of much study, especially by Russian investigators. Most of the work has been done in two laboratories, one directed by Pavlov and one by Bechtereff.¹ The primary interest of the studies has been to unravel the physiological mechanisms underlying behavior changes, to discover the manner in which the cerebrum functions. Dogs were employed as subjects, and each laboratory has centered its studies around changes in the stimulating conditions which evoke a specific response, the flow of saliva in the

¹ The Oxford University Press has recently published *Conditioned Reflexes*, by I. P. Pavlov. This book is the first complete discussion of conditioned reflexes to be translated into one of the more familiar languages. It is the outcome of thirty years' study by Pavlov and his colleagues.

laboratory of Pavlov and the flexion of the leg in that of Bechtereff. As a result of these investigations, together with studies of the effects of extirpation, these investigators have been enabled to present a rather complete and satisfactory picture of cerebral function. Our present interest leads us to mention the findings mainly as they reveal the environmental conditions which must be fulfilled if learning is to take place. The findings of the two groups are in almost perfect accord, and the results of similar experiments carried out elsewhere are consistent. For this reason we may limit our discussion mainly to Pavlov's investigations.

His research has been conducted under rigorously scientific conditions. The dog to be studied is placed in a sound-proof room and at first is harnessed. The experimenter makes his observations through peepholes, gives the various stimulations by means of controls located outside the room in which the dog is placed, and has apparatus for mechanically recording the time and amount of salivary secretion.

The salivary flow is released in most experiments by feeding powdered meat. This excitation to the dog's taste receptors is effective without training and is termed an *unconditioned stimulus*. The ringing of a bell originally elicits no salivary reaction and may be termed an *ineffective stimulus* until training makes it effective when it is called a *substitute stimulus*, since it is then substitutable for powdered meat. When a response is elicited by a substitute stimulus, it is called a *conditioned response* or *conditioned reflex*.

A. The Fundamental Requirement for Conditioning.

The essential requirement in transforming an ineffective stimulus into a substitute one is that it be given simultaneously with or preceding an unconditioned one. A dual presentation, *i.e.* the presentation of an ineffective stimulus with or before an effective one, we shall refer to as a *pairing*. After repeated pairings of powdered meat and the sound of a bell, the ringing of a bell alone causes a flow of saliva. In a like manner any

other excitant that may be paired with powdered meat becomes substitutable for it.

Some stimuli which are ineffective in producing a flow of saliva are effective in releasing some other response, *e.g.* an electric shock originally produces no salivary action but does cause flinching or retraction. A stimulus of this sort may be made substitutable provided it is not too intense. The stimulus to be substituted must not of itself set off a reaction stronger than that of the stimulus whose place it is to take. Apart from this limitation any stimulation whatever—cold, warmth, light, sound, odor, pressure, pain—may be made a substitute one.

B. Effects of Increasing the Number of Pairings.

As the number of pairings is increased up to a maximum, the substitute stimulus becomes increasingly effective. This heightened cogency is revealed in six ways to be discussed in the next six paragraphs.

1. *After a limited number of pairings the substitute stimulus does not set off a response unless the total situation obtaining during training is reproduced.* If a dog is fed while in a harness and standing on a table in a particular room and a bell is rung with each feeding, the dog must be placed again in the harness on the table in the same room to make the bell effective in producing the flow of saliva. In a sense, then, the bell is not the conditioned stimulus, but rather the total situation is responsible for the flow in the absence of the unconditioned stimulus. What has happened is that the salivary action is now released by a situation which lacks one detail of the original. As the number of pairings is increased, an increasingly greater number of details may be dropped from the original situation until eventually the bell in almost any surroundings will set off the salivary flow. The dog need no longer be harnessed and may be placed in another room.

2. *After a few pairings the bell also fails to be effective if it is accompanied or preceded by some stimulus which was not present during training.* One of Pavlov's students found irregularities

in the effectiveness of the substitute excitant and traced them to the presence of a fly which by its buzzing introduced a distracting or inhibiting factor into the situation. To test this explanation he, when testing the effectiveness of the bell, sounded an electric buzzer sometimes just before and sometimes just at the ringing of the bell and found that the potency of the bell was temporarily destroyed or lessened. Stimuli which are not present during training and which are destructive to the effectiveness of others are termed *inhibitors*. As the number of pairings is increased, the substitute stimulus is less subject to inhibition. Students may enter the room and converse without altering the effectiveness of the bell.

3. *After a few pairings the conditioned stimulus under the most favorable conditions sets off only a feeble response.* As the number is increased, it comes to elude as strong a reaction as the unconditioned excitant.

4. *After a limited number of pairings, other stimuli which resemble the one being made substitutable are also effective although originally they had no potency.* For example, if a tuning fork is used in training, one having a much higher or lower pitch, or even any noise, evokes the flow of saliva. As the number of pairings is increased, other stimuli to be effective must approximate more and more closely the one to which the dog has been trained until eventually only those very nearly the same as the true substitute bring reactions. In an experiment by Anrep, a tuning fork whose vibration rate was 637 per second was employed, and training was carried to the point where only those between 594 and 680 vibrations per second were effective. Excitants similar to the substitute one can be made ineffective more rapidly if during training they are introduced unaccompanied by food. In this case the dog is always fed when the substitute is presented.

5. *It is further found that the greater the number of pairings the greater the number of times the substitute stimulus is effective when given unaccompanied by the unconditioned one.* If training has not been carried far, the substitute excitant is effective

only once by itself. After training has proceeded for some time the substitute of itself repeatedly evokes the salivary action.

6. *Similar to the last effect is the fact that the effectiveness of the substitute is retained for a length of time proportional to the amount of training.* After a few pairings it is ineffective fifteen minutes after it has last been paired, while after much training it retains its potency several months.

C. The Effects of Varying the Time Interval between the Ineffective and the Unconditioned Stimulus.

This school of investigators has found further that the closer the temporal relations between the substitute stimulus and the unconditioned one the greater is the amount of conditioning as measured by any one of the changes mentioned under B. When the food and bell are given nearly simultaneously, the conditioned response is readily established, but when the sounding of the bell precedes the giving of food by more than two minutes the conditioned response does not appear until after many pairings. One investigator, Anrep, built up conditioned responses when the substitute excitant preceded the unconditioned one by various intervals up to thirty minutes. He found a direct relation between the length of the interval and the resemblance between the substitute stimulus and others which would be effective (number 4 under B). With a thirty-minute interval very dissimilar stimuli would call forth a response, with a twenty-minute interval less dissimilar ones, and so on to the cases in which the interval was practically zero when great similarity was required. In other words, he found that many pairings with a long interval give the same results as a few pairings with a short interval.

If the ineffective stimulus always precedes the unconditioned one by exactly the same length of time, the conditioned response follows the giving of the substitute stimulus by that length of time. In case there has been much training with an interval of exactly one minute, the flow of saliva starts one minute after

the bell is rung by itself. This is one of the most baffling of the discoveries from the study of conditioned responses.

D. Summary of the Conditioned Reflex Principles.

We have outlined the major conclusions from the many experiments on conditioned reflexes, as these experiments throw light upon the sort of training demanded for learning. Let us bring them into summary form.

(1) If a stimulus is to be substituted for an unconditioned one, it must be given with or before, never after, the unconditioned one.

(2) The excitant to be substituted must not of itself set off a reaction stronger than that evoked by the unconditioned stimulus. In other words, to be conditioned a response must be the dominant one at the time.

(3) After a few pairings, (a) the substitute excitant is effective only if the situation in which it was paired is reproduced without subtractions or additions, (b) the conditioned response is feeble, (c) it is elicited by stimuli quite dissimilar to the one which was paired with the unconditioned stimulus, (d) it is evoked by the substitute stimulus only if that stimulus is given shortly after training, and (e) it is set off only once or at most a few times by the substitute stimulus unaccompanied by the unconditioned one.

(4) After a number of pairings (a) the substitute excitant is effective in almost any situation, (b) the conditioned response is vigorous, (c) it is elicited only by those excitants which closely resemble the one used in training, (d) it may be evoked long after training has ceased, and (e) it may be repeatedly set off by the substitute stimulus alone.

(5) The more nearly simultaneously the stimuli are given, the more rapidly is progress made toward the conditions expressed in (4).

To these conclusions may be added three others not discussed above.

(6) A conditioned reaction is more readily developed to a

given excitant after it has already been developed to some other. For example, it is easier to condition the salivary secretion to a flash of light after it has been conditioned to the ringing of a bell.

(7) A stimulus comes to evoke a response by being paired with one which has gained its effectiveness through conditioning. For example, after the salivary secretion has been thoroughly conditioned to the ringing of a bell, a flash of light may be made effective by pairing it with the bell. This is called secondary conditioning. This suggests a restatement of the fundamental requirement for conditioning to read as follows: a stimulus which repeatedly precedes a reaction, whatever the cause of that reaction, becomes capable of evoking it.

(8) If the substitute stimulus has the same duration in every pairing, it must, when presented alone, have that duration to be effective. For example, if the bell is sounded for one second each time it is rung with feeding, it will bring no salivary flow if it is sounded by itself for more or less than a second.

E. The Physiological Basis of Conditioning.

If the question of the physiological explanation of the conditioned reflex is raised, it must be admitted that details cannot be given. For our purposes it will be sufficient to recall the discussion of the functioning of the cerebrum. The two summarizing statements provide a general conception of what happens in the nervous system. The unconditioned excitant sets up strong neural impulses to a particular responding organ or set of responding organs. Impulses arising from the ineffective stimuli are deflected so as to pass also into this effector or group of effectors. In traveling this route, these deflected impulses leave modifications of such a character that subsequently impulses arising from the ineffective stimulus are more likely to go into the responding organ of the unconditioned stimulus. Several theories have been advanced regarding the nature of these modifications, but no one is sufficiently satisfactory and generally accepted to warrant discussion here.

F. Simple Conditioning and Man's Learning.

The reader no doubt has thought of many instances of simple conditioned responses in man's behavior. The sight, smell, or mention of an acid food frequently causes one's mouth to water. To name it subvocally, to think it, is often sufficient to bring about this reaction. The sight of a bleak scene makes us shiver as if with cold. Fear is aroused within us when we encounter an object which by chance was present when we were once frightened. In succeeding chapters it will become more and more apparent how much of our actions is composed of simple conditioned responses. Having accepted the conclusions from Pavlov's investigations, we are not obliged to go into the laboratory and study under rigidly controlled conditions the development of the responses in which we are interested. We need only show with reasonable certainty that a reaction has been repeatedly preceded by a given stimulus to account for the fact that it is evoked by that stimulus.

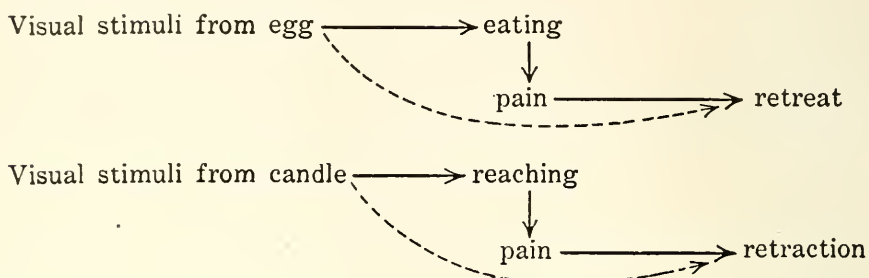
OTHER TYPES OF LEARNING

Much animal as well as human learning appears to be quite different from simple conditioning. Some of these differences are more apparent than real. Their nature can best be shown by describing the various other types of learning and discussing them in the light of what we have learned about simple conditioned responses.

A. Substitution of Response.

Often a stimulus comes to evoke a response different from the one which it originally elicited. A baby at first reaches to a candle flame but later draws back at the sight of the flame. A dog which eats eggs will learn to avoid them if he has encountered some treated with cayenne pepper. In both cases the original response has brought the organism into contact with pain stimulation which without learning evoked retraction. Later the stimulus which gave rise to approach brings about retraction or retreat. A diagram will show how this occurs

and how closely the reaction resembles a simple conditioned response. The unbroken lines indicate the original stimulus-



response connections and the broken ones the acquired relation. If we leave out of consideration the original response to the visual stimuli, the diagram is identical with the diagram for simple conditioning. When viewed in this manner, the noxious stimulation is the unconditioned one, and the visual stimulation is the ineffective one which gains an effectiveness through training.

In describing simple conditioning, we were not interested in the response originally belonging to the ineffective stimulus. Had we been interested, we might have noted that an electric shock when paired with food not only gains effectiveness for setting off the flow of saliva but also loses to some extent its power to evoke flinching or retraction. A shock which at first brings a marked flinching brings no wincing after training. If the intensity is increased, a retraction again results, but with additional training even this increased strength fails to cause flinching. Conditioning results not only in increasing the effectiveness of a stimulus for one response but also in decreasing its effectiveness for others. The difference between substitution of response and simple conditioning is that in the former we take special note of the response originally belonging to the ineffective stimulus, while in the latter we do not. In describing changes in behavior, it is necessary to give attention to this response, while in considering how a stimulus gains an effectiveness, it need not be taken into account. It will be well to remember that

whenever an excitant gains an effectiveness for one response, its effectiveness for others is correspondingly decreased.

B. Negative Adaptation.

In substitution of response a stimulus, as it loses its adequacy for the response originally linked with it, takes on an effectiveness for evoking some other reaction. Under other conditions it not only loses its original effectiveness but fails to evoke any reaction whatever. Noises which keep us from sleeping when we are unaccustomed to them later pass unnoticed. A dog not only learns to avoid eggs but comes to disregard them. This form of change, a developed disregard or negative adaptation, is also closely allied to simple conditioning. A dog, after retreating from an egg, is acted upon by other stimulations. A cat may come into view, the master's call may be sounded, another dog may approach. If one of these stimulations always presented itself immediately after the dog had encountered eggs, the sight of eggs would through simple conditioning come to set off the response belonging to that stimulus, *i.e.* substitution of response would result. If the master always whistled just after the dog had seen an egg, the sight of an egg would cause the dog to turn and go to his master without being called. But the same stimulus is not always present just after eggs are encountered. As a result, the sight of eggs becomes partially conditioned to many responses. The amount of conditioning to any one response is not sufficient to cause its release by the sight of eggs. Partial conditioning to many responses should theoretically decrease the effectiveness of a stimulus for setting off the act originally linked with it just as a great deal of conditioning to one response results in this decrease. The fact that the dog which has once eaten eggs ceases to notice them is a result of the variability of responses made after leaving the eggs. The rule of negative adaptation may be stated as follows: *Any stimulus which is followed by numerous and varying activities loses its effectiveness in evoking a definite response.* If a person goes into a factory where there is much noise, he is at first

distracted; but if he remains in the factory and occupies himself with numerous tasks, the noise will in time pass unheeded.

C. Trial and Error Learning.

1. *Description.* Much of the investigation of learning done by American psychologists has involved the training of animals to thread mazes or to effect their escape from problem boxes.

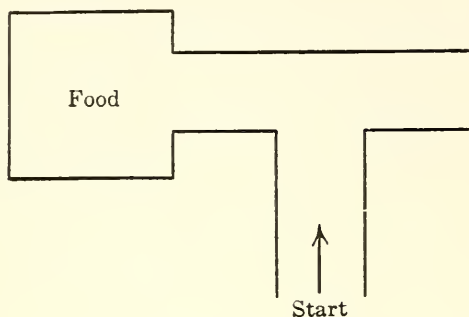


FIG. 20.—The simplest T-maze. The food compartment may be placed at either the left as shown or at the right. The other arm may be closed or the animal may be picked up and restarted after passing through the open end.

The simplest maze is one in which there is one path that is closed or blind and one which leads to food, a mate, a nest, or some set of conditions in which the animal will be contented. (See Figure 20 and also Figure 22 which is a photograph of a special form of the T-maze.) A problem or puzzle box is a cage from which the animal may escape by pulling a string, moving a knob or

lever, climbing upon a board, or performing some other act according to the design of the box. In releasing itself, the animal may eliminate the constraint of confinement, procure food, or reach a mate or some other desired object or condition. Both mazes and problem boxes may be complicated to any desired degree, mazes by including numerous *cul de sacs* as diagrammed in Figure 21, and problem boxes by requiring the execution of a number of acts in a definite sequence.

When an animal is placed in a maze or problem box, it displays a number of activities which do not result in bringing it nearer to food. These acts may be considered errors, and hence the activity involved is designated as trial and error behavior. After training, many or all the ineffectual acts are eliminated. The animal goes quickly and directly through the true path

of the maze or releases itself from a problem box without needless activity. Through trial and error, it learns how to obtain food under the conditions imposed upon it.

Much of the experimentation involving trial and error learning has been done with other interests than the determination of the nature of learning. Some investigators have been interested

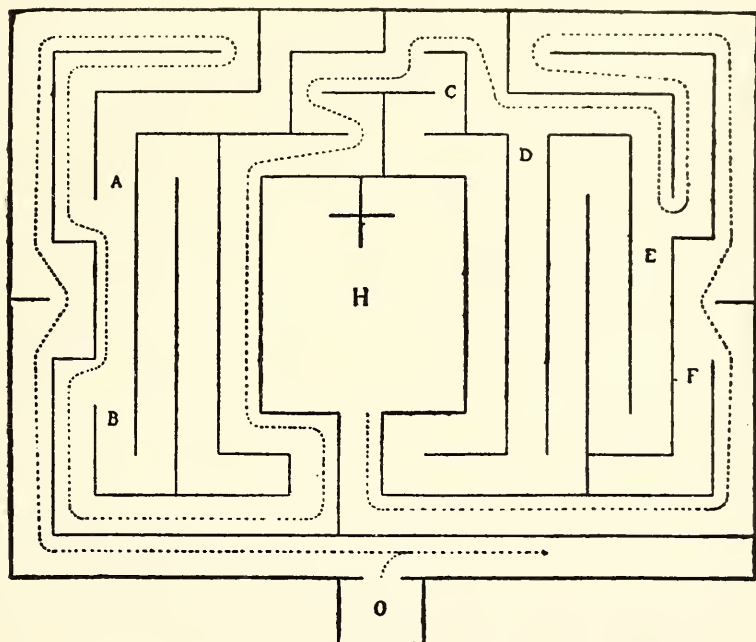


FIG. 21.—The Hampton Court maze. The animal is admitted at O. Food is placed at H. Complicated blind alleys or *cul de sacs* are shown at A, B, D, E, F. At C there is an alternate and longer way to food. (From Watson.)

in discovering the comparative learning ability of various species, others in determining their relative aptitude in discriminating brightness, pitch, or other stimulus-qualities, still others in discovering the comparative efficacy of various incentives and forms of punishment, food as compared with the opportunity to mate, the restraining effect of an electric shock as opposed to the inducement of food, aversion to passing through water as compared with passing through extreme cold.

In these experiments there are certain requirements which must be fulfilled if learning is to occur, and an examination of these requirements may be expected to throw some light on the nature of learning.

The control box shown in Figure 22 has been used in many experiments. Suppose that it is employed to teach a white rat

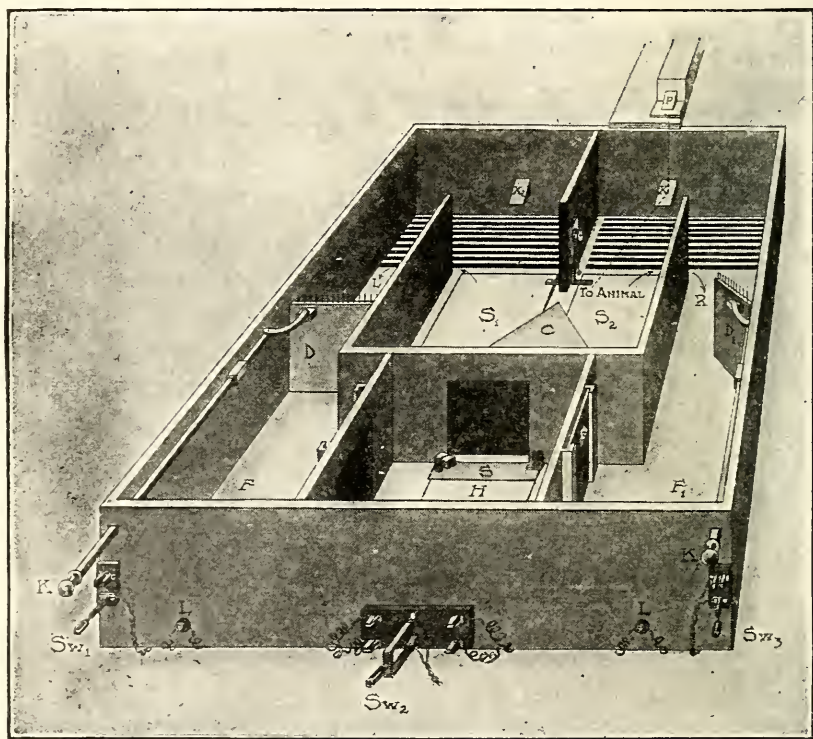


FIG. 22.—The Yerkes control box. Explanation in the text.
(From Watson.)

to turn right. The door (D) on the left is closed, the one (D') on the right is opened, and food is placed in compartment F'. A rat which has been without food for a day or more is placed in compartment H. Then the door leading forward from H to C is opened, and as soon as the rat has passed through it, it is again closed. The rat may now move about any part of the maze except compartments F and H. In the course of its move-

ments it enters F' and the experimenter closes D'. While in F' it finds and eats the food placed there. After it has eaten, it is replaced in its housing cage until the experimenter desires to give it another trial, or it is allowed to pass from F' to H and is immediately given another trial. After a number of trials the rat goes rapidly and without needless steps to compartment F' as soon as the door between H and C is opened, whereas on the first trial it may have consumed several minutes in reaching F'.

In an experiment of this sort it will be noted that a discontented rat, *i.e.* one which is hungry, is used, and there are open before it two possible paths of which one leads to food and the consequent removal of hunger. The rat learns the means of obtaining food. In describing trial and error learning, four features stand out: (1) The animal is acted upon by a persisting and disturbing stimulus or condition. (2) In response to this persisting stimulus and the situation in which it finds itself, it executes various responses in its activity repertoire. (3) One or a series of these acts results in the removal of the persisting stimulus. (4) With repetition most or all responses which do not contribute to the removal of the persisting stimulus are eliminated. This describes trial and error learning whether the persisting stimulus is hunger, confinement, denial of the mating activity, or any other condition under which the animal is restless and whether the responses which remove the disturbing condition are those involved in following a definite path or in the manipulation of a latch in a problem box or in surmounting some obstacle encountered in the animal's natural habitat.

2. *The conditioned reflex explanation.* This learning is superficially quite different from simple conditioning, and several theories have been proposed to account for it. Perrin and Klein² distinguish and discuss nine. Their presentation is admirable, and so we shall attempt to bring out only the relation between trial and error learning and simple conditioning. Smith and Guthrie³ hold that the relation is close, that in fact trial

² *Psychology, Its Methods and Principles*, pages 218-243.

³ *General Psychology in Terms of Behavior*, pages 119-130.

and error learning is to be accounted for in terms of the principles of simple conditioning.

The essentials of the conditioned reflex theory are: (1) that an active animal is employed in order that the response or set of responses to be linked with the maze or problem-box situation will be exhibited each time the animal is placed in that situation, (2) that through simple conditioning some elements of the situation lose and others gain in effectiveness, and (3) that the animal is fed or otherwise rewarded not for the sake of giving pleasure but to terminate the reactions to the maze or problem box.

Many animals when placed in a maze are inactive and so do not execute the act which is necessary to the attainment of food, or if they do perform it, they do so only after a great elapse of time. A rat when not hungry sits and scratches itself or lies down in a corner. It may be made more active by allowing it to become hungry. Its activity may be further increased by repeatedly feeding it in the maze. A hungry rat within sight and smelling distance of food moves rapidly and directly toward it. If a definite stimulus or set of stimuli repeatedly precede the securing of food, the presence of this stimulation comes through simple conditioning to cause the animal to dash forward. This conditioned heightened general activity is noticeable in animals of almost any species when the keeper comes to feed them. Since a definite set of stimuli is involved in transferring a rat from its housing cage to the maze, an animal which is repeatedly fed in a maze becomes conditioned to making a greater number of movements and to executing its movements more rapidly when placed in the maze. In other words, a rat which has been fed in a maze runs instead of pausing, twisting, and scratching. Since running is a forward movement, the rat does not rear or turn about until it is confronted by an obstruction. Several investigators, especially Warden, and McDowell and Vicari, have noted that the elimination of back-tracking is one of the first effects of maze training and that this elimination is not an indication of the learning of the maze problem. Dashiell has

found that blinds pointing forward are more frequently entered, less readily eliminated than those leading from the true path at right angles.

If a highly active, forward-moving rat is placed in a maze with only one runway, it of necessity repeats the same series of movements trial after trial. This gives rise to the formation of a serial habit, one in which the stimulations arising from one response evoke the next response.

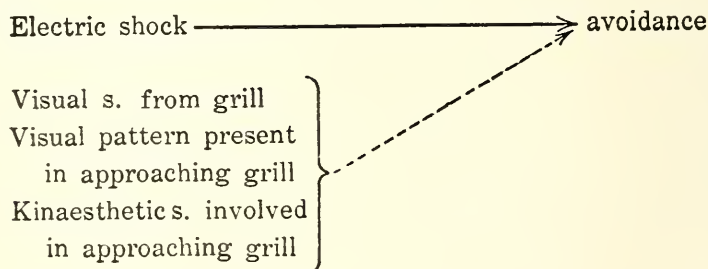
a. EXPLANATION OF A RAT'S LEARNING TO TURN RIGHT. If a highly active, forward-moving rat is placed in the control box of Figure 22 with door D closed and D' open, it repeatedly makes the same set of movements after entering the alley on the right and in consequence develops a serial habit which functions from the entrance of the alley to F'. But before the rat enters this alley, it may turn left and enter the closed alley. To learn the problem set for it, it must cease entering the alley at the left. The crucial point in learning to turn right is, then, the learning to eliminate the turn to the left.

The elimination of the entrance into blind alleys is a matter of substitution of response. The open end of an alley which was originally entered by an untrained rat is avoided by a trained one. It encounters the closed door and must turn back. At first, retreat may be made only after some delay. It may scratch at the edge of the door, stand on its hind legs, or make other reactions to the obstacle in his path, but because the hunger stimuli persist it finally leaves the alley. When it enters on a later trial, it turns back with greater promptitude, still later it retreats when only part way to the closed door, and eventually ceases to enter this alley at all. Several experimenters, particularly Joseph Peterson, have observed that animals enter blind alleys less and less deeply as training progresses and that if blind alleys are similar in all respects excepting in length, entrance into them will be eliminated in the order of their length, the shortest first.

The elimination of the *cul de sacs* is accounted for by the fact that there is a definite set of stimuli which precede retreat, and

these become substitutable for blockage. These substitute stimuli may be visual, olfactory, or kinaesthetic, but since most mazes are constructed in such a manner that the entrance of blind and open alleys are visually alike, and since most experimenters deodorize the maze after each trial, the stimuli must be mainly kinaesthetic. It may be remarked, however, that the fact that the entrances to all alleys are visually alike does not eliminate visual cues. When the rat turns right in the control box, there is an alley visible to its left; and when it turns left, there is an alley visible to its right. This visual pattern of stimulation and the kinaesthetic pattern as the rat approaches the alley to the left become the substitutes for blockage and cause the animal to turn away from the alley.

This explanation of eliminations is supported by the fact that an animal ceases to enter blind alleys in fewer trials if it encounters an electric shock or other noxious stimulation as it enters the alley. In using the control box to teach a rat to turn right, the grill S may be electrified, and then when the rat treads upon the grill, it jumps back. After a few experiences it avoids the grill. This learning may be represented as follows:



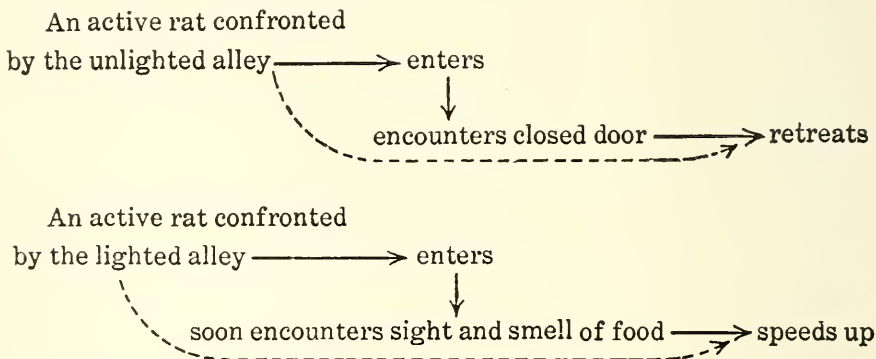
In avoiding the blind alley, the rat must, after passing through the door leading from compartment H, turn either right or left. If it turns left, it encounters the wall and must turn right. If it turns right, it may continue to food without obstruction. After it has learned to avoid the alley to the left, its passage through the door leading from compartment H is always followed by a right turn. As a result, the stimulation arising as it passes through this door comes to evoke a right turn. In this way

there is perfected a serial habit which functions from the time compartment H is left until the alley to the right is entered, which carries the rat past the crucial point in the maze. We have already described how the serial habit involved in going through this alley to food is established.

In recapitulation it may be said that the animal by being fed in a maze becomes more active when subsequently placed there, that when fed it ceases for a time to respond to the maze, that it builds up a serial habit which carries it through the alley leading to food, that there is established a conditioned avoidance of the blind alley, and finally that, since in avoiding the blind alley it must turn right, there is developed a serial habit which involves a turning to the right in response to stimulations arising as it leaves compartment H. In short, it seems that the learning to turn right in a maze is a matter of building several conditioned responses simultaneously, a matter of conditioning the animal to be active, to avoid certain regions of the maze, and to make a number of movements in sequence. If this explanation is valid, it becomes clear that it is not necessary to suppose that the rat has foresight, has any ability to reason that it must make a given set of movements in order to procure food, nor is it necessary to suppose that the satisfaction, the consequence of its learning, enters into the explanation of that learning. The rat's learning may legitimately be *described* as a learning of the means of obtaining food, but to *explain* it by reference to this result does not seem legitimate. As we said in Chapter 2, it is useful to describe behavior in relation to its consequences, but to explain it in terms of those consequences is unscientific.

b. EXPLANATION OF A RAT'S LEARNING TO TURN TO THE LIGHTED ALLEY. Having presented a conditioned reflex explanation of trial and error learning as it is shown in a simple maze problem, let us note its application to more complicated problems. Suppose that the control box of Figure 22 is used, as has frequently been the case, in a discrimination experiment. Stimulus-patches X and X' are made different from each other.

The experimenter imposes upon the animal the necessity of reacting to this difference if it is to procure food. As a simple case, suppose that when one stimulus patch is lighted the other is unlighted and that the door on the lighted side is open, *i.e.* when X' is lighted D' is open, and when X is lighted, D is open. When D is open, food is placed in F , and when D' is open, food is placed in F' . To go to food without error the rat must turn always toward the lighted alley. This it learns to do after a number of trials. The appearance of the unlighted alley becomes the substitute stimulus which evokes avoidance, and the appearance of the lighted one becomes more and more effective in eliciting rapid and unhesitating approach. The learning may be diagrammatically indicated as follows:



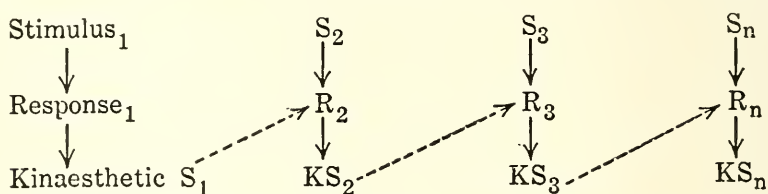
C. EXPLANATION OF A CAT'S LEARNING A PUZZLE BOX. To apply this explanation again, let us suppose that a cat is placed in a box whose door may be opened by pulling a lever. The cat need not be kept without food, for when it is confined, it becomes highly active. Greater activity may be induced by allowing it to become hungry and then placing food just outside the box. When placed in confinement, it claws and bites the box, particularly in the region of cracks. The disturbing confinement continues until in its scratching, the lever is lowered, *i.e.* its attack upon any part of the box except the lever is followed by a response to some other part. Retreat is made from all parts except the lever, and consequently the stimuli arising

from these parts come through simple conditioning to evoke avoidance. As soon as the lever is pulled down by its clawing, the cat ceases to react to the box, no retreat is made, and in the course of repeated trials it comes to react only to the lever.

We may reiterate that random activity promotes learning, for a random act brings the organism under new stimulating conditions, and through simple conditioning new modes of responding are built up. Trial and error learning is in a sense a misnomer since the organism need not be conceived as trying to accomplish anything nor as making errors. Knowing the nature of the persisting stimulation, we know also the nature of the act which must be executed if that stimulation is to be removed. If an animal is hungry we know that it must secure food to remove the hunger. Since it is more active when hungry, we describe its activity as a seeking for food, and any act which does not contribute to the obtaining of food we consider an error. If a normally quiet animal becomes highly active when confined, we know that its heightened activity will disappear when it is released, and so we describe its behavior as an attempt to obtain release. The desire for food and the desire to escape do not exist as entities, as psychical forces. The term desire may be useful in description and possibly for explanation. If used for the latter purpose, it must be conceived as the stimulations leading to activity and the mechanisms underlying responses, as suggested by Holt in *The Freudian Wish*. If we, constructed as we are, touch a hot object, we have a desire to withdraw from it. The desire is either a description of the fact that we do withdraw or it is the stimulation and the sensori-neural-motor construction which causes us to withdraw. If a rat goes without food, it develops a desire for food. The desire is either a description of the fact that it does obtain food or it is the hunger stimuli and the organismic construction which causes it to obtain food. This meaning obviates the necessity for the word, because the designation and description of the stimuli and the stimulus-response mechanisms are sufficient to account for the behavior displayed.

D. Serial Habits.

In practically all trial and error learning, several reactions are bound together in sequence through the response-derived stimuli. Suppose that instead of using a maze with only one possibility of turning right or left, one which has several such possibilities is employed, as *e.g.*, the one diagrammed in Figure 21. The animal becomes negatively adapted to each blind alley in the same manner in which it learned to disregard the left alley in our first illustration, and thus comes to run through the maze without error. If later it is blinded, it is still capable of performing perfectly. This ability is retained even though all external receptors are made inoperative by means of local anaesthetic. The explanation must, by exclusion, be in terms of conditioning to the kinaesthetic stimuli. One response has been repeatedly followed by another, and the response-produced stimulation from the one has thereby become a substitute for the next. The diagram below represents this conditioning.



Kinaesthetic conditioning may also be shown in puzzle-box performance. Suppose that instead of finding it possible to open the door by lowering a lever, the animal is required to do this and then to pull a string with its teeth. If, after it has learned to do this, the string is removed, it will be observed to pull the lever and then turn as if to pull the string. The first act, having been repeatedly followed by the second, comes to elicit it.

When a number of acts are linked together by response-derived stimuli, the group is referred to as a serial habit.

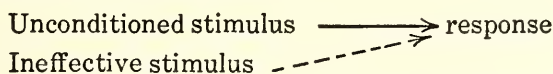
SUMMARY

Five types of learning have been distinguished, and their explanations seem to reduce to the fundamental principle that

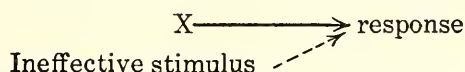
a response which is preceded by a definite excitant tends subsequently to be released by that excitant. The physiological explanation seems to lie in the inter-influence of neural impulses and the permanent modifications resulting when impulses arising in one receptor are deflected into new channels through the influence of activity in other paths. It does not seem necessary to postulate any non-physical factors in accounting for changes in behavior.

The following diagrams may serve to represent the changes marking each type.

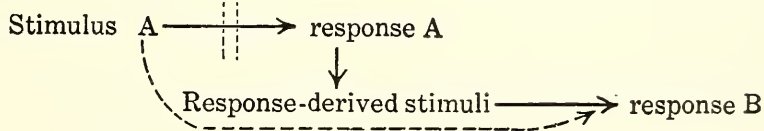
(1) SIMPLE CONDITIONING



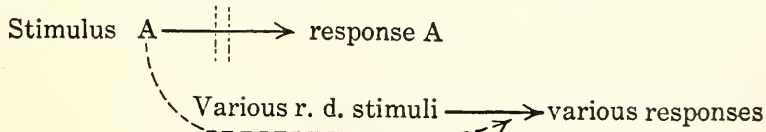
or



(2) SUBSTITUTION OF RESPONSE

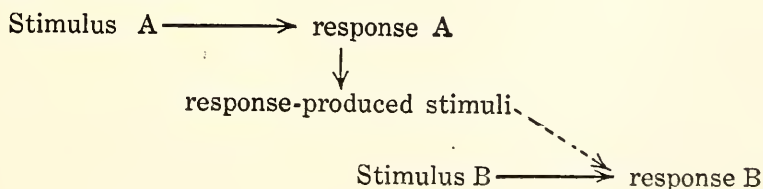


(3) NEGATIVE ADAPTATION

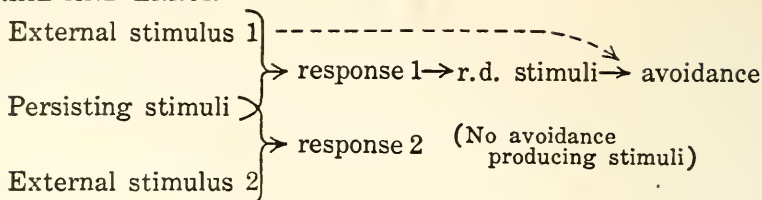


(The conditioning from stimulus A to any one of the various responses is not sufficient to release it.)

(4) SERIAL HABITS



(5) TRIAL AND ERROR



QUESTIONS AND EXERCISES

1. Early schools of psychology referred development in behavior largely to association of ideas. The conditioned salivary response would have been described as the formation of an association of the idea of bell and that of food. In what ways is the concept of conditioned responses an advance over this older view?

2. What is the relation between conditioned reflex principles 4d and 4e and what is commonly conceived as forgetting? Does a piece of paper which has been folded forget?

3. Give examples (a) of a response being evoked by a stimulus similar to the substitute one, (b) of a stimulus which is effective in the original situation being ineffective in a changed situation.

4. A student in one of the author's classes presented the following explanation of negative adaptation. A conditioned response is first developed, *e.g.* a conditioned nausea evoked by the sight of a food which has made the individual ill. With time this conditioning diminishes so that no nausea is produced, but there remains sufficient conditioning to prevent eating. The individual neither feels nauseated at the sight of the food nor inclined to eat it. At this state he may be said to be negatively adapted toward the food. Compare this explanation with the one given in the text.

5. If we possessed a detailed physiological explanation of simple conditioning, would it be necessary to develop a physiological explanation for the other types of learning?

6. With the help of the Psychological Index and the index number of the Psychological Abstracts prepare a bibliography of ten or more recent articles on the conditioned reflex. Review three of these articles.

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CHAPTER 9

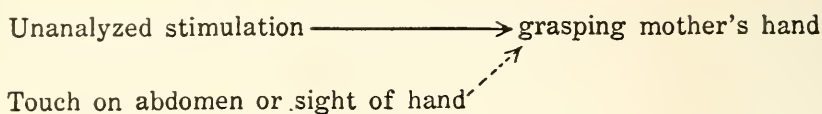
MANUAL BEHAVIOR

On the basis of the responding organs involved, a reaction may be said to be skeletal, visceral, or verbal. As previously indicated, no response is purely of one type, but in its adjustive significance is considered as being of one sort. In this and the two subsequent chapters we shall trace the general features of the development of these three classes. The present chapter will deal with the development of skeletal or manual responses.

THE EYE-HAND CO-ORDINATION

Among the first reactions of this type that come to bear a definite relation to their stimuli are the arm and hand movements. At about six months of age the infant begins to reach to things within his field of vision. The question arises as to how this development comes about, whether by maturation or by learning. In the case of one infant the first definite reaching was to the mother's hand while she was changing the napkin. In the course of the baby's random movements he chanced to touch the mother's hand. The resulting contact set off the grasping reflex which in turn caused the arm and hand to be held in a definite location for an extended time. During this period the eyes were fixated upon the mother's hand, and in addition there was contact stimulation of her hand on the abdomen. These conditions are the ones necessary to make the visual and contact stimulations substitute excitants capable of arousing movement of the arm in this direction. After the mother's hand had been grasped several times by chance, it would be immediately seized when the abdomen was touched

or when her hand was fixated in this position. This may be represented as follows:



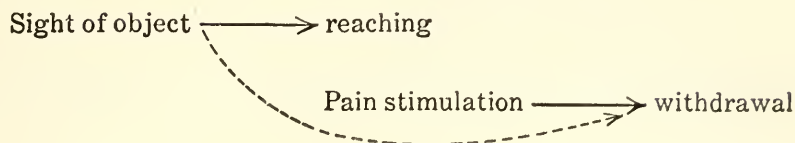
When, now, the mother held her hand near the place to which the baby had learned to reach, he extended his hand as before (conditioned reflex principle 3c), but since no contact resulted, he continued his random movements until he grasped the mother's hand in the new position. After being taught in this way to reach to several new positions the baby soon reached immediately to her hand anywhere in his field of vision and within his grasp. The baby had learned the eye-hand co-ordination, to extend his hand to whatever stimulated him visually. The reaching responses were at first made in a random way, but when a particular reaction out of the many was preceded by a definite stimulation, that stimulation came to set off the reaction. In other words, the eye-hand co-ordination is a group of specific conditioned reactions.

Bottle-fed babies learn to hold their hands on the bottle. At first this is brought about in random movements, but soon the sight of the proffered bottle brings the hands immediately to it. Nearly all babies have within possible reach some object and will strike this by chance and then later will extend their hands to it whenever their eyes are fixated upon it.

VISUAL DISCRIMINATION

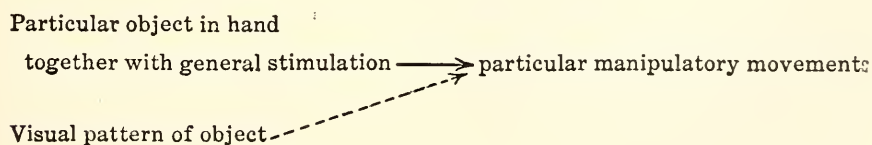
These responses are developed to any and all objects within the visual field and within reach. The baby extends his hand to a burning match, to soap or glue or anything in sight. As he reaches to various objects, he receives further stimulation which determines succeeding responses. If the infant reaches to a hot object, the stimulation to the pain receptors elicits a withdrawal. The baby learns to avoid reaching to these objects as the dog learns to abstain from eating eggs after this action

has led to pain stimulation. Diagrammatically what happens is this:



From the very nature of the stimuli which arise from objects, certain ones will come to be avoided. There are others which for various reasons the parents wish the baby to avoid. They arbitrarily add pain stimulation while the baby is looking at the object and thus build up avoidance as effectually as if the object itself had furnished the pain stimulation. The introduction of the pain stimulation or punishment when the object is not in the visual field will obviously not teach avoidance. If at any time, due to the ineffectiveness of a single conditioning, the baby reaches to an object and receives no pain stimulation, the previously established tendency toward avoidance will be weakened.

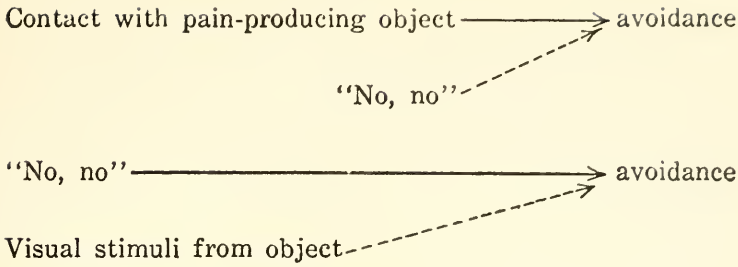
Not only does the reaching response make it possible for the baby to discover what objects to avoid, but it also enables him to learn how to handle or manipulate others. When he chances to touch an object, he grasps and holds it. If it is movable, the continuation of his random reactions causes motion of the object. His possibilities of action are to some extent determined by the nature of the object; certain movements are made while grasping one and others while grasping another. Since the visual pattern afforded by each precedes or accompanies the movements made in handling the object, the stimulus-pattern of the object tends to set off these manipulatory movements. This is simple conditioning and may be represented schematically as follows:



When we say that the visual stimuli tend to set off determinate movements, we mean that they produce a tension in the muscles used and also such changes in the gradient pattern of the nervous system as will favor the overt performance. *To see* (not merely to be stimulated by) an object is to respond either overtly or covertly in a specific way to the visual stimuli arising from that object, *i.e.* to respond in a way different from the manner of responding to other objects. Specific responses are termed discriminations. Visual discriminations are conditioned responses built up through the occurrence of definite patterns of visual stimuli along with certain reactions such as withdrawal and random manipulation. The implicit character of many discriminations will be considered in detail later. For the present we are concerned with indicating that random arm movements, together with the clasping of the touched object, give rise to both negative and positive ways of responding.

CONDITIONING TO VERBAL STIMULI

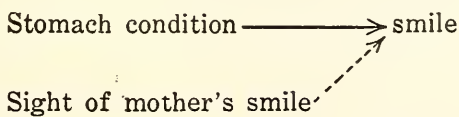
The mother's interest in the welfare of her baby leads her to warn him of objects which give rise to pain stimulation. When he is about to touch something hot, she calls out a warning, "No, no." This at first means nothing to the infant; it does not arouse an avoidance response. He proceeds to touch the object, and the avoidance reaction is evoked. Since the warning has now preceded the avoidance, it becomes a substitute excitant after a few repetitions, provided the mother is careful to call out only in case the baby is reaching toward something in itself harmful. Later the "No, no" sets off withdrawal even though the object toward which the infant is reaching is not itself harmful. Still later the visual stimulation from this object, having accompanied the "No, no" also causes avoidance. The latter is a case of secondary conditioning. The successive stages in this learning are summarized in the following diagrams. In this case the baby is beginning to understand language, *i.e.* to have his reactions determined by word stimuli, and the mother is beginning to assert verbal control over his behavior. This



illustrates simple social control and has in it practically all the essential components of complex social control. Other instances in early life are numerous. The baby develops the habit of putting out his hands when the mother says, "Come." He has learned in the manner we have discussed to reach to the mother's hands. If, when she extends her hands, she also says, "Come," the word causes the baby to stretch out his arms (to be taken?) without the mother first extending hers. He learns to show how big he is by putting his arms high above his head. He chances to do this in his random movements, and the mother says perhaps, "How big." After a few repetitions the words "How big" lead him to raise his arms. In a like manner other little "tricks" are acquired.

LEARNING TO IMITATE

The mother not only verbalizes the baby's behavior but also imitates it. When he happens to raise his arms, she playfully imitates. Soon the baby, seeing the mother put up her hands, does likewise. Perhaps the earliest instance of learned imitation is the smile. The contented baby just after feeding smiles—nurses call it a stomach smile. The mother is pleased and smiles. Soon the sight of the mother's smile leads to one on the part of the baby. The following diagram will make this clear. In a



like manner the waving of "bye bye" is learned. The mother first imitates and so brings about the conditions necessary to

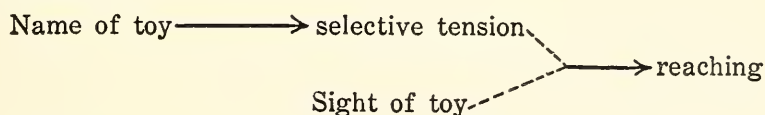
make her movements a substitute excitant for a similar performance on the part of the infant. Gestures as well as words come to be responded to in definite ways. We must emphasize that *imitation is learned*. After the infant has learned to imitate, he may then learn by imitating as we shall point out later.

PREPARATORY AND CONSUMMATORY RESPONSES

Another instance of verbal control will serve to illustrate a more advanced or complicated type of learning. Suppose the mother is anxious, as most mothers are, to have the baby identify his toys when their names are spoken. As she hands the child a toy, she pronounces its name. After a time the baby will select from a number of toys the one mentioned by the mother. In the cases previously discussed the substitute language stimulus sets off its response almost immediately, while in this case the picking up of the designated toy may be delayed for some time while the baby is looking about from one toy to another (to find the correct one?). There is a number of seeking, hunting, preparatory, or anticipatory responses leading up to and terminating in a consummatory one. Just as the hungry rat's restless or exploratory activities may be described by saying that he is seeking food, so may the baby's searching or exploring be described by saying that he is seeking the toy which the mother has named. These responses are, however, not explained by imputing a purpose to the rat or the baby. It is the observer who foresees the consequences.

The rat's behavior we ascribed to the persisting internal stimulation of hunger and the various elements of the external situation. For the baby the general stimulation is the word spoken by the mother, and this is external and of short duration. The question to be answered has to do with the baby's persistence until he finds the designated toy. Our first clue is that there may be some persisting effect from the spoken word. We have seen that activities in handling or playing with the various toys are specific for each. The mother by naming the toy as it is handed to the baby establishes the conditions necessary

to make the name a substitute excitant tending to set off these movements. (See the diagram on page 175 and substitute "Name of object" for "Visual pattern of object.") The play responses are, however, not consummated until the visual stimuli from the toy are also active. Nevertheless they tend to be set off. There is produced by the spoken word a heightened tension in the muscles used in handling the toy named and such changes in metabolism in the nervous system that the gradient pattern is altered. There are kinaesthetic stimulations arising from the first effect, and there is abundant evidence to show that the impulses from this type of stimulation tend to be delivered back into the muscle from which they arise.¹ This circular feeding of impulses into muscles once innervated tends to prolong the response. The gradient pattern imposed by a stimulation also tends to persist as we have seen in the study of the amoeba. There are, then, two persisting effects from the spoken word, and both make the individual more ready to respond to a particular excitant and less ready to react to others. This accounts for the fact that the baby does not react at all completely to any excitant until his toy is seen. The following diagram, in which the term "selective tension" denotes the two persisting effects, makes clear the conditions underlying this behavior.



Often when behavior persists and leads toward some end reaction, we say that there is a purpose guiding it. If by "purpose" is meant a particular internal and persisting physiological condition of the sort just described, there can be no objection to saying that it guides behavior. Since this is not the common connotation of the word, we shall use instead the term maintaining or persisting tension. It will be noted that the tension is removed by the responses which it favors, or, popularly

¹ Beritoff gives data to indicate that these circular pathways are established by conditioning. See *Brain*, 1924, pages 409 ff.

speaking, the purpose is fulfilled; one achieves his purpose when certain reactions have been made. We shall find in the next chapter that visceral tensions are prominent as maintaining stimuli and that they are removed by the responses which they favor.

As the individual becomes older, the reactions which lead up to some consummatory response (which remove maintaining tensions or achieve purposes) grow increasingly numerous. By repeated stimulations equivalent to saying that a person should become a doctor, the long series of activities leading up to this profession is initiated and consummated. The responses at any one time are determined by both the maintaining tension and the external circumstances. To the hunger tension one learns to make a great number of preparatory responses not only in etiquette but also in securing and preparing food and in earning money with which to make the necessary purchases. All of us have acquired many groups of habits, each being referable to some end reaction or to some maintaining tension. To refer them to the end reaction is advantageous in description; to ascribe them to the maintaining tension is helpful in explaining as well as in describing them. A particular group of these habits is often referred to popularly and in some textbooks of psychology as an instinct. There are three reasons for rejecting this terminology: (1) These groups are for the most part learned, not unlearned, reactions. (2) The distinction between heredity and environment is impossible. (3) Instinct commonly connotes a non-physical force or drive which, granting that it exists, is not subject to scientific treatment. The fact that an act has as one of its effects or consequences the preservation of the race or the individual allows it to be described as self or race preservatory, but to say that the act is caused by an instinct of self-preservation or one of race-preservation is to depart from the fundamental principles of science, is to say that behavior is explained by its consequences. In this chapter we are not interested in listing and describing various groups, but rather in finding the principles underlying their development, and we do not believe that they are explained by referring them

to mysterious instincts. Their explanation is, we hold, in terms of the internal and external conditions affecting the organism and the physiological characteristics of that organism. We shall offer a more critical and more complete treatment of the instinct doctrine in a subsequent chapter.

A significant point which bears upon anticipatory responses and which has not yet been mentioned is that our receptors empower us to respond to objects and other excitants which are at a distance. After the child possesses the ability to walk, he goes to a toy which stimulates him from a distance. He may also go into the house when his mother calls him to dinner. In both cases he reacts not only to the distant stimuli but also to the more immediate ones, steps, doors, intervening objects. The reactions leading to the picking up of the toy or the arrival at the dinner table are the resultants of the tensions set up by the sight of the toy or by the sound of the mother's call and stimuli arising from the more immediate surroundings. It is plain in these cases that the child is not responding to future stimuli but rather to maintaining tensions and external stimuli. Yet if we were to ask an adult who was on his way home what was determining his responses, he would be inclined to tell us that it was something in the future. He might, however, reply that it was his thoughts of home that were guiding his present behavior, that through his ability to think of home it was *as if* home were in sight. If his latter statement is true, we possess in language the possibility of carrying the world of objects around with us and of having them in this substitutive form stimulate us much as if they were actually present. In a later chapter we shall examine our language responses and will then decide as to the accuracy of the foregoing conclusion.

It may be further pointed out that the nature of our preparatory acts is to a large extent determined by others, by social customs and regulations. The child in removing his hunger must learn to use knife, fork, and spoon—later knives, forks, and spoons—to wash before eating, and to wait until others are seated. As in responding to the call to come he has to react to

As adults we often learn how to do things from being shown. We are already capable of making the separate movements involved, and the learning is a matter of acquiring the proper sequence. After following each movement as it is performed before us, we can soon go through the series without the demonstration.

A large amount of our learning is from oral or written instructions. We have already noted how isolated words come to release characteristic movements. Single words may also come to trip off a series of movements. Suppose the child has learned to draw lines in response to seeing them drawn, and that the mother draws a series to form the printed capital letter "E." If she says "E" or "Make E" as he is imitating her movements, the child soon learns to perform the act when told to do so. The auditory stimulus leads to the making of the first line and the derived kinaesthetic stimuli to the drawing in succession of the other lines. If, after the child has learned to make several letters, he is told to write a word, each letter at first must be pronounced by the teacher, but soon the spoken word leads to the writing of the letters in sequence. A new sequence of movements has been learned from oral instructions and may be elicited by a brief command. In the chemical laboratory the student may be given the task of testing for the presence of chlorine. At first he must be told or must read how to go about this, but after a few repetitions the instructions may be dispensed with.

We also learn to instruct ourselves with our own verbal responses. If someone demonstrates how to build a fire without matches, we need not immediately make the manual movements to profit by the demonstration. Rather we verbalize the movements, saying to ourselves, "First this is done, then that, next this, and finally that." Then as we start to repeat the performance manually, it is guided by the recall of these verbal responses. Our own verbal responses made subvocally may direct our skeletal responses in a way very similar to instructions from others. The discussion of how we develop the

ability to verbalize the behavior of others and of how verbal responses come to direct manual ones must be postponed until the chapter on the development of language. The concern at present is to point out that our manual habits are bound up with language, whether it is written, oral, or subvocal, and that things learned through verbal stimulation are new sequences of old movements.

WANTS OR DESIRES AND THEIR EXPRESSION

The discussion of this chapter has centered in man's behavior as it is determined by his fellows; it may also be regarded from the standpoint of the development of the ability to influence others. This control over others is exerted early in life. Suppose a pin is pricking a baby. This without learning causes crying which leads the mother to pick up the baby and remove the pin. We would not hold that the baby cried in this case to be picked up, but he soon learns to cry without the presence of pain stimulation, and we are then tempted to say that he cries because he wants to be picked up. Let us examine this learning and inquire into its explanation. While the pin is pricking the infant, many other stimuli—the pattern of touch stimulation from lying in bed, the sight of the mother, and the sound of her steps as she approaches—are operative. These come to elicit crying without the presence of the pricking pin. The mother concludes after searching for a pin that the baby merely wants to be picked up. The crying is a conditioned response and does serve a purpose but is not made for that purpose. We *describe* this sort of behavior in which there is elicited from another person an act that puts an end to the stimulation by saying that it expresses a want or desire. The want or the desire can be nothing more than the stimulating conditions which gave rise to the response. Not all stimulating conditions are considered wants, only those that lead to responses that either directly or through the mediacy of another person remove the stimulating condition.

If the baby is crying in response to a conditioned excitant, it

ceases when the mother draws near. The mother's approach has previously been followed by the removal of the noxious stimulation and this by the normal reactions of the contented baby in his mother's arms. The sight of the approaching mother now tends to set off these responses of contentment and hence the cessation of the crying. But her propinquity has been followed by a definite series of stimulations involved in being picked up. If the mother fails to continue with the series, more vigorous crying ensues. The series of responses being initiated tends to go through to completion, but the mother's failure thwarts these movements and brings about the unlearned stimulation for anger. The stimulation giving rise to the original crying is augmented by visceral stimuli, *i.e.* it is emotionally reinforced. We may add this characteristic to our above definition: *A want or a desire is the emotionally reinforced stimulation which gives rise to responses which either directly or indirectly remove the stimulating condition.*

When a want is present, any reaction that tends toward its removal is said to give pleasure or be pleasant, and any response or stimulating condition that increases the want is said to be unpleasant. When we want food, eating is pleasant and anything that thwarts eating is unpleasant. Pleasantness and unpleasantness refer, then, to changes in the intensity of those stimulating conditions which we call wants. We have, in discussing trial and error learning, pointed out the fact that we retain those responses which remove the want and abandon those which intensify it. It is permissible to say that we learn to respond to those stimuli which give pleasure and to avoid those which give rise to unpleasantness. This describes the course of learning but in no way explains it. The explanation is the one given under the heading of trial and error in Chapter 8, that when acted upon by a persisting stimulus, we at first make varied responses and in so doing learn from the nature of external stimuli encountered to avoid all those which block or delay or offer pain stimulation.

Some wants are largely unlearned, *e.g.* the want for food,

while others are learned, *e.g.* the want to be picked up. The outstanding features in the acquisition of wants are (1) the development of serial response from a repeated sequence of stimulation, and (2) the thwarting of these responses by the absence of the usual sequence of stimuli. Another instance of a learned want will serve to emphasize these features. The baby, in playing with a toy, drops or throws it from his bed, and the nurse picks it up. After this has happened several times, the baby, as soon as he drops a plaything, looks at the attendant as if to say, "Come and pick it up." The nurse's series of actions serving as stimuli to the infant has led to the establishment of a serial habit in the baby. He has repeatedly dropped his toy, fixated the attendant, and followed her movements as she has picked it up and restored it to him. It is, then, only the natural result of conditioning that the response-produced stimuli from dropping the toy lead to the fixation of the attendant. If she fails to pick up the toy as usual, *i.e.* if she does not present for the baby the customary sequence of stimulation, crying or some other expression of his desire to have her procure the toy ensues. In approximately this fashion we come to want companionship, homes, and many other things that we as adults desire, and in this sense we come to anticipate conditions which do not as yet exist.

In the light of this analysis of the development of wants and their expression it becomes plain that wants and maintaining tensions as we have defined them are one and the same thing. We have added to our discussion of preparatory and consummatory responses chiefly by showing how a person develops as preparatory responses those which will enlist the co-operation of others. It is quite essential that we learn to express our wants in such a way that others will understand what is expected of them.

SUMMARY

To recapitulate, we may say that man from his many originally random responses and from a few definite reflexes learns according to the principles of the conditioned reflex to make

countless specific reactions. These may be grouped into three classes: (1) positive or reaching and manipulating responses, (2) negative or avoidance reactions, (3) social reactions, (a) those made in response to others and (b) those that serve as stimuli for others. They might also be grouped on the basis of the want or desire about which they center. The underlying wants may be learned or unlearned.

QUESTIONS AND EXERCISES

1. What does a month-old baby see? To what do you attribute its inefficiency?

2. In the light of the present chapter elaborate the statement of Chapter 7 that "even though in infancy his (man's) responses are for the most part random, they are rich in variety and lead him into new stimulus-combinations which afford the groundwork for learning."

3. Why does the mother come to possess such a stimulus-potency for the infant? How is this an advantage to the child in his acquisition of adjustive responses?

4. It seems that purpose commonly denotes something within us, something that influences overt behavior, and something which is non-physical. To what extent is this conception acceptable? To what extent are the purposes which a person possesses the outcome of training?

5. What would be the results if we were deprived of our kinaesthetic receptors?

6. Discuss anticipation or expectancy in relation to simple conditioning and serial responses.

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CHAPTER 10

VISCERAL BEHAVIOR

We have defined visceral behavior as activity in the smooth muscles and glands. Much of this activity need not be stressed in psychology since it is concerned more directly with vegetative responses. On the other hand it does influence and modify manual and verbal behavior, and the psychologist is interested in discovering the extent of its influence. Visceral activity is not only response but also stimulus. Many of the stimulating conditions to which we referred as wants are in large part stimuli arising from the viscera. Hunger is a case in point. In addition to acting as stimulations to the internal sense organs, visceral conditions may affect the activities in the nervous system and in this manner modify the skeletal responses. The ductless glands pour their secretions into the blood stream, and these secretions become a factor in the environment of the nerve cells and centers.

In describing visceral conditions, we shall group them in three classes: (1) those that normally are continuously present but which in exceptional circumstances become disrupted, (2) the emotional conditions, those that are present only when some special stimulating condition is active, (3) the appetites, those that arise after protracted absence of the materials used in metabolism or that result from the prolonged lack of excretion. We shall discuss them in the order given.

THE ENDOCRINE SYSTEM

In the experimental control of development, as, for example, the control of the distance between fishes' eyes, a common method is to place either a depressing or an accelerating chemical about the developing part. The chemical regardless of its type

will have its greatest effect upon the region normally higher in metabolism, *i.e.* upon the high end of the already existing gradient. If the chemical is depressing in character, it tends to equalize the rate of activity in all portions, *i.e.* to destroy the gradient. The destruction of the bilateral gradients in the fish's head in this manner determines the development of a single eye in the center. If the chemical is accelerating, it will tend to make more marked the already existing differences in rate of activity, *i.e.* will tend to steepen the gradient. An augmentation of the bilateral gradients in the fish's head in this manner determines the development of eyes abnormally far apart. The secretions or chemicals emitted by the ductless glands logically have one or the other of these effects upon the gradients of the nervous system although little work has been done with a view to showing this directly. If behavior is an expression of the gradient patterns in the nervous system, there is much evidence to uphold this reasoning. Let us consider the effects of glandular secretions upon manual behavior.

The *thyroid apparatus* consists of two thyroid glands connected by an isthmus and of four parathyroids, one below and one above each thyroid. In general, the secretions of the thyroids and parathyroids are antagonistic, and the balance between the two kinds *controls the rate of the basal metabolism of the body cells*. If the thyroid secretion becomes excessive or the parathyroid deficient, metabolism is accelerated, while in the opposite condition metabolism is depressed.

The former type of disturbance is a large element in exophthalmic goiter. The behavior effects in which we are chiefly interested may be described by saying that the individual is markedly nervous. The slightest stimulus brings a rapid response involving an abnormally large part of the bodily musculature, *i.e.* the individual is hyper-sensitive and hyper-active. The nervous discharge is not confined so definitely to specific channels but rather it is diffuse. This brings into use muscles which interfere with efficient adjustment. In walking, the muscles normally little used by others contract markedly. In

other words responses are inco-ordinate. The individual is also highly distractible and jumpy. There is a tendency to react to any and all stimuli. This picture of behavior is the one that would be expected if cell metabolism were speeded, if all gradients were steeper. A sense organ would then tend to dominate many muscles. Strychnine produces much the same effects and is known to be an accelerating chemical.

The effects of deficiency of thyroid secretion are known as Cretinism if present from birth and as Mxyoedema if the onset comes later in life. General cell metabolism is low. A chronologically old Cretin behaves much as a child, in pronounced cases as a child of only one or two years. In the case of Mxyoedema the individual's activity reverts toward the infantile. In both cases action is slow and sluggish. There is hypo-sensitivity and hypo-activity. This correlates well with studies of animals on which depressing chemicals are used. The gradients tend to be destroyed, the dominance of one region over another is lessened, and retarded development results.

It may be mentioned in this connection that the performance level is often referred to as mental age. If a person is capable of doing only the things that the average child of three years can do, he is said to be three years old mentally. By intelligence is meant the relation between chronological age and performance level. If the performance level is six years and the chronological age is twelve, the individual is unusually dull, while if the chronological age is four, he is exceptionally bright. It may be mentioned further that mental age is usually tested in verbal habits, and consequently intelligence, as the term is used in connection with tests, refers to the verbal ability possessed by one individual in comparison with others. Artistic and mechanical ability are obviously a part of the total performance level. These abilities and their testing will be considered later. The point of interest at present is that manual and verbal abilities depend in part upon glandular activities.

If a Cretin or an individual with Mxyoedema is fed thyroid extract, the performance level as well as the general physical

condition improves. A reversion in both is noted with the cessation of treatment.

The effects of the secretions from other ductless glands are more specific, particular syntheses and oxidations being influenced rather than the general metabolism. The *pituitary gland* through its secretions *affects chiefly the syntheses giving rise to bone structures*. Excessive secretion causes undue bone growth or gigantism, while deficient secretion results in dwarfism. The *ductless sex glands*, the cells of Leydig, *control the development of those structures which differentiate the sexes and also determine manual behavior characteristic of the sex*. If the ductless sex glands of a female guinea pig be transplanted into a male, the male develops the secondary structural characteristics of the female and also behaves much as a female. There is some direct and much indirect evidence which indicates that the femininity of some men and the extreme masculinity of some women is due to abnormal ductless sex glands. *The pineal inhibits activity of the sex glands*. With its decay these begin functioning at a new rate and determine the rapid development of sex characteristics as they are shown at puberty. New visceral conditions and new desires appear rather suddenly. Society has ruled that these wants may be removed or satisfied only in conformity with social standards, just as the parents require that the child satisfy his hunger in compliance with definite rules of etiquette. Conflict arises between the desire for direct satisfaction and the demands of society. The thwarting of the former leads to rage and may lead to the development of anti-social habits. The effects of these visceral conditions are obviously far-reaching.

The remaining ductless glands we need not consider since their effects on behavior are less important or, if important, are not known. The effects of the thymus are still little understood. In fact the discovery of the functions of the ductless glands is quite recent. The understanding of them is so important that a special branch of physiology has been developed and is known as endocrinology. The reader may consult books on this subject for more detailed information.

THE EMOTIONS

In contrast with the activities of the glands which we just discussed is the activity of the adrenals. These secrete only when certain excitants, which for the present may be referred to as emotional stimuli, are active instead of secreting continuously and uniformly as do the others. The secretion of adrenalin has effects almost identical with the changes produced by impulses passing out over the thoracic-lumbar division of the autonomic system. It increases the rate and strength of the heart beats, raises blood pressure by constriction of the blood vessels, causes a redistribution of the blood since it constricts chiefly those of the viscera, induces the release of more sugar into the blood from the liver, causes the blood to clot more readily, decreases or stops activity in the digestive and reproductive organs, and most probably affects the gradients of the nervous system in much the same manner as thyroid. It thus gives rise indirectly to particular internal stimulating conditions and directly to special gradient conditions. Both results affect skeletal behavior.

A. Definition.

These profound and temporary changes in the viscera, whether caused by the secretion of adrenalin or by impulses passing out over the autonomic system, are the emotions, or at least a large part of emotional responses. Whether we are to mean by an emotion only visceral disturbances as determined by definite excitants or to mean the visceral disturbance together with its effects on manual behavior is an arbitrary matter. In this book we shall mean only visceral behavior when we speak of the emotions.

B. Infantile Emotions.

Watson concludes from his investigations that there are three true emotions: fear, rage, and love. Fear and rage are closely allied, the secretion of adrenalin and its effects being a large factor in both. The adrenal glands do not, however, become active alone. The system which innervates the smooth

muscles and glands acts in two antagonistic divisions, the thoracic-lumbar and the cranial-sacral. Action in either is characteristically diffuse which means that if there are impulses delivered to the adrenal glands, there will also be impulses delivered at the same time to other visceral parts. Fear and rage are both the result of thoracic-lumbar activity, but the pattern of discharge in fear has in all probability many differences from the pattern in rage although the exact differences are not at all well known. One outstanding difference is that in fear the blood vessels near the surface of the body constrict causing a pallor, while in rage these dilate causing a flushing. Rage then may be said to be one visceral pattern and fear another, although there are many components common to the two patterns.

Love as an emotion is in all probability a visceral pattern determined by cranial-sacral discharges. It is of a nature in general opposite from fear and rage. The word love is used also to refer to other than purely emotional conditions. Sometimes it alludes to the sex appetite, to be discussed presently, and is then usually spoken of as passion or passionate love. Sometimes it pertains to the attachments formed for some object or person, as for example the devotion of the mother to her child. In these cases it is a love of something. These attachments are the end-result of having built up many responses to an object or person. If this object is removed from the environment, the routine of behavior is disrupted. Thus we have the anomaly of a husband who, although he quarrels constantly with his wife, misses her tremendously when she is away and wishes she were back. The neighbors, observing his dejection, decide that he really loves his wife in spite of gossip. The explanation is to be found in the previous chapter. The object or person that comes to be loved is a factor in building up serial habits which are thwarted by the removal of the object. A baby who is repeatedly picked up by one person comes to be adjusted to that person's manner of handling him, *i.e.* to be ready to make a response when the condition for making it arises. If someone else picks him up, he

is not prepared to make the responses demanded, in fact is set to make other responses which are thwarted by the unusual handling, and crying ensues. This we take as evidence that the baby knows the person with whom he is constantly associated and that he loves this person.

C. Unconditioned Stimuli.

In the infant these emotional responses are set off by only a few stimuli. Watson concludes that only loud sounds and sudden jarring elicit fear, that only hampering of movements results in rage, and that tickling, particularly of erogenous zones, gentle patting, rocking, and mild jostling, especially when the baby is placed on its stomach across the mother's knee, elicit love.

D. Substitution of Stimuli.

Through conditioning many excitants gain a potency for releasing the various visceral patterns. The substitute stimuli for fear reactions become especially numerous in the course of most of our lives. These stimuli become effective through simple conditioning. Infants enjoy playing with furry animals, but, as Watson found, if a loud sound is produced while they are so engaged, the baby will thereafter fear the animal as well as other animals which are furry. One evening a two year old boy, romping on the lawn, screamed and exhibited other symptoms of fear when someone began to whistle, "Yankee Doodle." The author at once suspected conditioning and made inquiry. He learned that two evenings previously the boy had been playing when someone had whistled for a dog. In response the dog had come bounding into the yard and knocked the boy over. A colleague told the author of a conditioned fear developed in his infant. The mother offered the baby a toy and just as she did so the baby sister screamed, "Mine." For some time the baby cried or whimpered when this toy was seen. A student told of a fear of musical instruments which he had as a child. As a small boy he was examining his father's horn when the father thoughtlessly blew a loud blast. Several pages could be filled

with similar reports from students. Each reader can in all probability think of fears developed in this way. It will be noted that one pairing of the unconditioned and the substitute excitant is sufficient and also that other excitants resembling the substitute one in only a general way become effective. The baby that is made afraid of rabbits will also fear other animals. The boy who was terrified just after the whistling for a dog was later frightened by the whistling of a tune.

Frequently a person carries a strong fear throughout the major part of his life. It may be quite mysterious to him and to his friends as well as disconcerting in many situations, leading him to reason that there is something peculiar or inferior about himself. These fears date back to an early childhood conditioning, so early that it is not remembered, or to a conditioning occurring under such circumstances that the verbal account is not made. A case analyzed by Bagby is relevant. A girl twenty years old had a strong fear of running water. She could not go for a walk or ride without first making sure she would not be obliged to pass a running brook. The sound or sight of water running from a faucet was highly disconcerting, at one time causing her to swoon. She took sponge baths, being unable to endure the splashing of a tub bath. On her twenty-first birthday her aunt whom she had not seen since childhood visited at her home. The greeting of the aunt was, "I have never told." At first the girl was puzzled, but finally recalled the following incident. When she was nine, she had gone on a picnic with her mother and her aunt. The mother had to leave early, and the little girl begged to be allowed to stay. Permission was granted with the promise that she remain close to her aunt. Her promise, like many of those of childhood, was not kept. The aunt missed her and after considerable search found her with her foot caught between two rocks at the base of a waterfall. The total situation for a girl of her age was one to bring about an intense fright, so intense that she fainted. The aunt, deciding that the girl had had sufficient punishment for disobeying, dried her clothes and promised not to tell the mother. She left next

morning before the little girl was up. This denied to the child the opportunity of verbalizing her experience and of learning other responses to running water. When at the later visit of the aunt she recalled the incident and reacted to it in an adult fashion, the fear disappeared.

Many extreme fears of this sort have been investigated with practically the same analysis as above, namely that the conditioning occurs in such circumstances that the experience cannot be reported to others, that reconditioning is impossible. An officer with a fear of closed places including trenches was conditioned from a sudden attack by a large dog when as a boy he was leaving a junk shop after selling his booty which was not obtained by too honorable methods. The entrance to the shop was in a very narrow alley, and subsequently confinement in any narrow or closed place brought out fear. Another individual had a fear of being grasped from behind. This dated back to a fright caused by a grocery-man. The boy regularly took peanuts from the barrel in front of the store and the grocer, deciding to put an end to it, hid behind the barrel. Just after the culprit had taken his handful of peanuts the grocer jumped out and shouted. In many cases such fears will disappear as soon as the happening in which they had their origin can be recalled. The psychologist has various indirect ways of helping in this recall. In case these fail, the retraining may be carried out in ways to be described presently.

The question may be raised as to whether or not some fears should be taught. There is, of course, little reason to learn fear of animals, fear of the dark, fear of water, but is it not a safeguard to learn fear of snakes and of moving automobiles? Is it not an advantage to teach certain fears as a means of controlling the child's behavior? The opportunity of utilizing fear in this manner is great. Many chance happenings similar to the following occur. A small child, soon after learning to walk, pulled a flower vase from its stand. It fell with a loud crash. The father saw what was about to happen but was too far away to prevent the catastrophe and so called out, "No, no."

Thereafter his "No, no" was quite effective in arousing fear with the accompanying avoidance. A child controlled in this manner will, however, become timid and too highly docile, and it may be questioned as to whether the gain in control offsets the disadvantages from developing these traits. Since avoidance can be taught through pain stimulation which does not arouse fear, it may be justly questioned whether any child should be deliberately taught a fear. The child may be taught habits of safety without arousing fear. By the time a child is permitted to cross a street alone he will have come to understand the language necessary to teach him habits that guard his safety. The parent on coming to the curb may tell him to stop, to look for automobiles first left and then right, and then give permission to cross only when conditions are favorable. Soon the child will make these responses without instruction, in fact may take delight in making the judgment for the parent. By correcting cases of poor judgment, the parent will soon have taught the child to be a good judge of when it is safe to cross.

In the case of anger there is a marked spread from the original hampering of movement. Not only is actual hampering effective but also any interference with one's plans and wishes. The object or happening which is present during the hampering, whether it be the agent of thwarting or merely a chance accompaniment, becomes a substitute excitant for anger. The sight of a person who has repeatedly interfered with us makes us angry whether or not he is at the time actively interfering. We say that we hate these individuals, or if the interference is not great, that we dislike them. We may come to dislike the sound of a telephone girl's voice after she has told us that the line is busy, for we tend to be angry with her even though we may know that she is really not at fault. We come to be made angry also by any interference with objects or persons to which we have become attached. They are necessary to the carrying on of our customary set of activities and the person who strikes at them strikes indirectly at us.

E. Negative Adaptation to Unconditioned and Substitute Stimuli.

In the case of anger particularly there is an increasing tolerance of thwarting, the original excitant. This is negative adaptation which was discussed in Chapter 8. The original excitant ceases to be effective through its occurrence in connection with other strong excitants just as the sight of eggs ceases to lead to approach on the part of the dog. When the child is thwarted in its eating, there are the persisting hunger stimuli which lead to acquiescence to the demands of the parents. When the child wants an object which the parents refuse to allow him to have, he will eventually forget about it and start playing with something else, or the parents may offer him some candy or other reward which will divert his attention from the thing desired. There is danger in this latter procedure as we shall point out presently, but it does in a way serve to make him tolerant of thwarting. The point to be made at present is that thwarting may at first lead to anger and its manual accompaniments, but that other conditions present at the same time or shortly afterward lead to the making of responses other than anger. Since these other responses differ from time to time, thwarting does not become effective in eliciting any one of them, and it also ceases to lead to anger. The neural impulses are drained at one time into one set of responding organs and at another occasion into a different set so that no one route is established and the original pathway is also obliterated.

This increasing tolerance for thwarting is a very important aspect of social adjustment. Living with others involves give and take, controlling and being controlled, being in some respects thwarted and in others abetted. The individual cannot always have his own way; he must make concessions to others. Needless to say, this tolerance should be developed as early as possible; otherwise the natural tendency of thwarting to set off anger will be augmented so that anger follows the merest trifle of interference. Developing it early in our present civilization

means developing it in the home. Too often this is not done; the child is spoiled. When he goes to the playground, he does not get along with the other children. They come to hate him and he to hate them; he develops an anti-social attitude. The supervision of play in order to help children form the habits of give and take is a phase of education often too little stressed, for it is in play activities that these habits are demanded and easily taught. The attendant teaches these habits here or in the home by not yielding when anger is displayed and by interesting the child in other activities.

Loud sounds and sudden jarring also lose their potency for arousing fear. At first glance it appears that this negative adaptation is built up differently from others. It seems that loud sounds lose their effectiveness simply by not occurring during childhood. But sounds do occur, and when their intensity is low, responses other than fear are made. This results in the neural impulses set up from noises being diverted into many channels other than those leading to the adrenal glands, and consequently louder and louder sounds may occur without arousing fear. In other words the original excitant by appearing in weak intensities must almost necessarily appear along with more dominating stimulation of other sorts and in this way comes to lose its potency even at great intensity.

One also comes to lose his acquired fears. These tend to die out unless there is reconditioning. They may be made to disappear more rapidly by either of two closely similar methods. The object of which the person is afraid may be brought within sight but kept at first at a distance. After he becomes accustomed to its presence at distance, it may be brought closer and closer until eventually it will not be disconcerting even at close range. A child had been made afraid of gold fish. These were placed by the parents in the far corner of the dining room. The child came to the table hungry, and although he noticed the gold fish, the food was sufficiently tempting to lead him to eat. In a few days he failed to notice the fish. They were then moved closer until eventually they were placed beside his plate

without arousing fear. With a little encouragement he began to give them food and to put his hand into the bowl. The other method is to introduce some excitant that elicits a vigorous response while the feared object is present. The clever parent will be able to interest the child in something else whenever he is mildly frightened. Suppose it is a new toy that is employed to divert his attention. The neural impulses set up by the fear excitant will be deflected into the responding organs involved in playing with the toy. This deflection tends to re-route the impulses from the fear excitant into other channels. We have already mentioned that fears carried over from peculiar childhood circumstances disappear in most cases when their origin is understood.

F. Modification of the Skeletal Accompaniments.

We have been examining the emotions chiefly as to their nature and in relation to their stimuli. They also act as stimuli affecting manual behavior. In a sense society does not care how often and under what conditions fear and anger result, as long as the skeletal behavior that is exhibited under their stress is socially acceptable. The original pattern of manual behavior that in infants accompanies each of the three primary emotions we described briefly in Chapter 7. In many cases this infantile pattern continues into adult life, in others it is replaced by other forms of manual behavior and we say that the person has learned to control his emotions, to direct them. This change comes about in a way essentially similar to the manner in which the individual learns to eat according to etiquette rather than according to early inclinations.

Fear and anger are persisting stimuli, and if the manual behavior originally set off does not aid in their removal, these responses are dropped and replaced by others that do help, as we discovered in considering trial and error learning. Suppose the child is thwarted and shows infantile rage or goes into a tantrum, as this pattern is termed in childhood. Suppose that the attendant concedes the point involved. The tantrum then

becomes not merely the natural accompaniment of rage but also a means of getting rid of the thwarting. The child comes to expect to enforce his demands by going into a tantrum. He has succeeded so often that he expects to be successful in all cases. Suppose, on the other hand, that the attendant refuses to yield. The child acted upon by the persisting stimuli and the external situation will make some other skeletal reaction or several such responses in random fashion, eventually making one that does remove the maintaining tension. In this way by his own efforts, by his own initiative, he removes the thwarting circumstances. Soon a hindrance is not something to set him into a wild and inco-ordinate rage but rather a challenge to his ability to eliminate it. He has learned that within his own reaction system there are possibilities of overcoming difficulties. He becomes the man with perseverance and initiative, because he has been taught it from the first. He is described as a man with a strong will power, the will power itself being merely the name for this way of behaving or the effects of his training as they are left in his nervous system and as they lead to this form of action.

In the case of fear the response that most readily removes the visceral condition is the retreat or fleeing response. Whether this response comes to accompany fright through maturation or through trial and error learning is of little importance. Most people do at some time in their lives behave in this way when frightened, while it is also true that nearly all outgrow it. If this change is analogous to the replacing of tantrums with other responses, we should expect that fleeing fails to remove fear. There are two senses in which this happens: (1) Through language we come to carry the world of objects with us and so cannot get away from feared ones. (2) New excitants in the form of the unfavorable opinion of one's neighbors are constantly placed in the path of the retreating individual. When a person is thus hemmed in by fear stimuli, obviously the retreat response is not very helpful; retreat from one set of fear stimuli leads to encountering another. The individual will then re-

main in position responding in part to the non-fear producing elements of the situation, *i.e.* responding much as if he were not afraid. He learns to conceal his fear. He may go further, for the more vigorously he makes responses which do not exhibit his hidden fear the more will his behavior be considered courageous and the less will he need to fear the possibility of socially imposed fear stimuli. Thus we have the anomaly of the soldier who although badly frightened shows the greatest courage. His courage, it is true, may on close scrutiny be seen to be superficial and of a nature more reckless than truly courageous. His fear leads him to overcompensate, to make the responses opposite to retreat more vigorously than he would do were he not afraid. In this way even fear may become a stimulating condition contributing to persistence in developing socially acceptable habits.

THE APPETITES

The third type of visceral condition mentioned at the beginning of the chapter we shall not discuss in any detail. Hunger is the outstanding tension of this type. Carlson has shown that it is the violent contractions of an empty stomach. It arises not as does an emotion through the action of some definite excitant, but comes about after the organism has been for some time deprived of food. The stomach contractions which give rise to the organic stimulation may nevertheless come to be set off by substitute excitants, the smell or sight of food, or the stimuli characteristic of the time of day. These stimuli have preceded the stomach contractions innumerable times. If one fails to eat for several days, the substitute excitants lose their potency and one ceases to be hungry. Thirst also belongs in this class of visceral tensions and comes to lead to the securing of liquids. In case the circumstances prevent the removal of hunger or thirst by a set of manual habits already formed, these tensions lead to random seeking movements, all other behavior becoming subordinated to the attempt to find water or food. Similarly if the oxygen supply is cut off or decreased, as in the case

of a person submerged in water or at a very high altitude, the same sort of frenzied seeking movements takes place. These three conditions, hunger, thirst, and oxygen deprivation, are similar in that they result from lack of materials necessary for nutrition and that they issue in manual behavior that removes the organic need.

Similar to these natural visceral conditions are those resulting from the deprivation of some substance, as for example a drug, to which the system has become adapted. By the repeated use of habit-forming drugs a want for them is acquired. In response to these wants, *i.e.* the conditions arising after deprivation, habits of securing and storing them are built up. If the already formed habits of removing the wants prove unavailing, restless seeking movements occur, just as in the case of failure of the manual habits for securing food or water.

Somewhat in contrast to those conditions arising from deprivation of materials used in metabolism are those resulting from the storing within the organs of the body of waste materials. As such materials accumulate, tension is exerted on the containing walls and stimulation leading to discharge arises. The mechanisms for expulsion are unlearned, but it is necessary to learn to conform to the standards of society in respect to time and place. The acquisition of these habits for the bowel and bladder tensions is relatively simple, but for the sex tensions, those resulting from the storing of the secretions of the duct sex glands, the rules of conformity are complicated. These rules need not be discussed here, other than to point out that many maladjustments have their origin in the failure to learn these standards both verbally and manually. Ignorance both of conditions underlying sex desires and of the justification for the social standards is blamable in large part for the maladjustments centering about sex.

VISCERAL BEHAVIOR AND ADJUSTMENT

While it is true that visceral activities are not in themselves adjustive, they have far-reaching effects upon adjustment. Man-

ual behavior depends upon the continuous function of the viscera. This function forms a continuous background for skeletal responses. In addition the temporary deviations in visceral activities cause pronounced variations in manual activity. Responses to external stimuli change as the visceral conditions vary. Furthermore these temporary conditions lead to the formation of habits for their removal. The sorts of habits formed depend not only upon the nature of the visceral condition but also on the nature of the external environment.

QUESTIONS AND EXERCISES

1. What are the dangers of an intense attachment? Of a narrow range of attachments? Are there sex differences in the intensity and range of attachments?

2. To what extent does fear enter into present-day discipline? Why do children, controlled by fear in early childhood, often become anti-social later? Discuss the adequacy of punishment as an effective means of controlling crime.

3. What are the differences between fear and the recognition of danger? Could a child under present-day conditions be reared without developing any fears?

4. In what sense have anger and fear outgrown their usefulness?

5. Start with some word, *e.g.* ocean, and write down each word of which you think without returning to the original word. Do you in the series come to some word with emotional significance? If so, how do you account for the fact? Try this with several words. Do you under these circumstances recall experiences of which you had not thought for some time? Do you think it probable that, if you had had some intense fright in early childhood about which you had forgotten, you might recall it in this way? One student in trying this serial verbal response ended with the word flashlight, and recalled an occasion on which as a very small child she had been intensely frightened by the taking of a flashlight picture. She had from that time been frightened by lightning and flashes from trolleys. After she recalled the incident, her fear of lightning was markedly diminished. Can you account for this last fact?

6. What are the distinctions usually drawn between anger and righteous indignation?

7. In the "give and take" of living, does one lose by making concessions and by being tolerant of certain forms of thwarting? Can you justify unselfishness from a purely selfish point of view?

8. Why do most people derive satisfaction from surmounting difficulties?

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CHAPTER 11

VERBAL BEHAVIOR

Parallel with the establishment of specific manual and visceral responses proceeds the evolvment of verbal reactions. The developments are considered separately mainly because the various types of responses have different adjustive consequences. The same principles hold in the development of all.

RANDOM VOCALIZATIONS

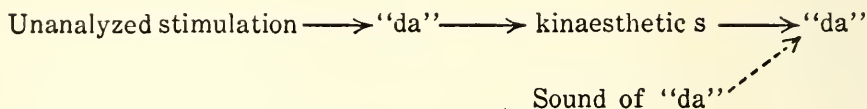
The baby exhibits not only random leg and arm movements but also random vocal utterances. It is to be remembered that in terming a response or series of responses random, we mean merely that it bears no observable relation to a definite stimulating condition. As Watson aptly puts it, "We do not know what button to press to release a 'da' response." Yet one scarcely doubts that there are stimuli or groups of stimuli that are responsible for each sound as it is produced. These random vocal utterances might better be termed anomalous reflexes.

The baby's vocalizations are at first monosyllabic, often merely vowel sounds but in many cases a combination of a consonant and vowel. Usually a sound is repeated several times. This repetition is commonly referred to kinaesthetic circular arcs, although it may be the result of the continuance of the general conditions which elicited the first sound of the series. The sounds resemble not the sounds of any one language but those of many, and so the baby may be said to have in his unlearned verbal repertoire the separate sounds which in combination form all languages.

VERBAL IMITATION

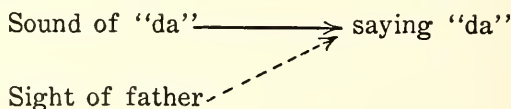
The baby learns to imitate sounds heard in the same manner that he learns to imitate movements seen. When he chances to

make a sound that resembles rather closely some meaningful syllable, the mother repeats and sets up in this way the circumstances necessary to enable the baby to learn to repeat what he hears. The earliest consonant sounds made are d, b, m, p, and g, while the earliest vowels are a as in at, o as in not, e as in need, and i as in it. Suppose the baby hits upon "da" or "ma." The parents are pleased since these resemble the baby names for father and mother. They repeat the sounds after him to encourage him to say them again. They are rewarded; soon, as early as three or four months, the baby says "da" or "ma" whenever he hears them. This can readily be seen to be a case of simple conditioning from the following diagram.



ATTACHMENT OF MEANING

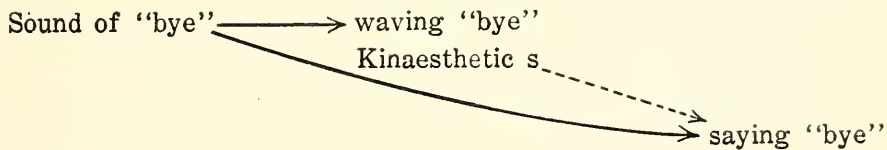
The baby has in the above manner made the first step toward using language as adults use it. His sounds, however, have no meaning to him. We do not call a response meaningful until it comes to be set off by the object to which the word applies. After the baby has been conditioned to say "da" in response to hearing it, he is taught to say it when he sees his father. A diagram will make discussion unnecessary.



We also speak of meaningless and meaningful stimuli or objects. An object or occurrence is said to have meaning when a definite response is elicited by it, *e.g.* the ringing of a bell has meaning when it comes to elicit the flow of saliva. Both responses and stimuli, then, are described as meaningful when they bear a definite relation to something else, a response to an excitant and an excitant to a response. In this sense the proton means to the electron something to be approached.

When a word is considered as a stimulus, meaning is attached to it in the ways that have been described in Chapter 9. If, when the mother says to the baby "Bye, bye," he waves "bye," her words have meaning, are reacted to in a definite way. He has understood what has been said.

Since verbal and manual developments proceed in conjunction, the baby says "bye" in connection with waving "bye." Both acts are a part of the pattern of response to the word heard. Both components of this pattern give rise to kinaesthetic stimuli, and so, if one act precedes the other, it will come to set off the other. If the baby has been conditioned to wave "bye" before he has been taught to say "bye," the waving will be more readily set off, and there will be the conditions diagrammed below. The result will be that any stimulus that sets



off a waving indirectly gives rise to saying "bye." The baby is then verbalizing his own behavior, telling what he is doing, introspecting, if you choose.

If training has been such that the first response is a verbal rather than a manual one, any stimulus that sets off the verbal response will indirectly produce the appropriate manual ones. The word spoken is not only a response but also through its excitation of the kinaesthetic receptors a stimulus to a definite manual reaction. Unless the word spoken does release or is bound up with other responses, manual or visceral or both, it has little meaning. One may go into a machine shop and be told that the instrument which he is viewing is a lathe and be able to pronounce the word lathe and to tell anyone else that it is a lathe, and yet neither the lathe nor the word will have much meaning until both are linked up with manual responses involved in the use of the tool. The word "da" has little meaning until it becomes associated with manual and visceral ways

monosyllabic stage, while the fact is that the baby learns to put various sounds together to form words and words together to form sentences. We have said that he learns to imitate syllables. Having learned to do this, he acquires serial combinations through imitation. Suppose he has learned to repeat "mu" and "da" separately. Their combination approximates "mother." To induce him to put them together, the mother pronounces "mu" and waits until he responds and then says "da." After a little practice he can say "muda" as explained in connection with serial learning. By the time the child is two or three years old, he can reproduce the separate sounds used in his parents' language and can imitate practically any word heard and also use words in a proper sequence to form sentences.

ABSTRACTION

Another development in our language is the acquisition of the ability to respond to parts of objects as if the whole were present. At first the baby says "da" only when he has a full view of his father. Later only a partial view, the sound of his voice, or the sight of a garment belonging to him are effective. Some of these items are always present whenever the word "da" is applied by the parents, while others are present only in occasional cases. The constant items become more effective in calling out the response and the variable ones less cogent or non-effective. This amounts to abstraction. Out of the whole group of stimuli to which the word is applied on various occasions are abstracted only those that are common to all cases. It is to be remembered that this happens in simple conditioning. If food is given in a variety of situations and if the ringing of the bell is common to all, it becomes the only substitute excitant that will cause the flow of saliva. The dog abstracts from the multiplicity of things about him while eating, only the one that means that he is going to be fed.

In these cases there is the development of a name to apply to the constant features of a changing object. Similar to this

is the acquisition of class names to apply to many objects having common characteristics. If the child is told to put a dish on the table, to bring a book from the table, and to do other things involving different sorts of tables, the word table comes to be applied not to a particular table but to any object having the elements common to all tables, legs and top, regardless of the size, shape, color. It is plain that this too is abstraction.

DEFINITIONS

In conjunction with the ability to abstract is found the development of verbal responses appropriate to the various features or parts of objects or classes of objects. The child learns to call coats, hats, noses, mouths, by their appropriate names. A coat worn by the father will then call out two responses, "da" and "coat." When this first happens, one response is as likely to precede as the other, *i.e.* the baby may say "coat-da" or "da-coat." The parents interpret either of these to mean father's coat and usually repeat, adding an affirmative and possessive, "Yes, Da's coat." This repetition favors the order used in adult speech and the addition of the 's so that soon the baby uses the correct order. The word "da" thus becomes linked not only with particular manual and visceral responses but also with further verbal responses. The child learns to state that "da" has a coat, hat, shoes, face, nose, and that a table has legs and top. He also learns to state that "da" is a man and that a table is an object. When in one sentence he states the class name and the possessions, he has given a definition, as *e.g.* "da" is a man and men have arms, legs, and heads.

Definitions of new words all give meaning to the word or to the object designated by it provided the words employed have been already linked up with manual and visceral responses. A lathe, defined as an instrument for shaping materials by causing them to revolve while acted upon by a cutting tool, becomes an object with meaning provided, of course, that one has had manual experience with instruments, with wood, with rotation, and with cutting and shaping. One could even work out from the

definition the sorts of shapes which could be imposed by a lathe. In this way we can experience things which have never existed in our immediate environment. They are brought to us in substitutive or symbolic form.

INTROSPECTIONS

We have been discussing mainly the development of verbal responses to external excitants. We have pointed out that manual responses may lead to verbal ones and that one verbal response may lead to another, *i.e.* a person becomes capable of describing his own manual and verbal activities. Visceral activities also come to be reported. We have seen that hunger may lead to crying and that acquired wants such as the desire to be picked up may also give rise to crying. By training, these tensions come to lead to other vocal responses. If the child is hungry, his responses will be of a generally restless and perhaps fretty nature although there may be no crying. The mother interprets the restlessness as indicating hunger and says, "baby hungry." The baby repeats for reasons already indicated. Soon he says "baby hungry" when hungry, without hearing it said by the mother. This is obviously simple conditioning. In the same manner the attendant who picks up the baby's toy for him makes some remark such as "get toy" in response to the baby's beseeching look. Soon the baby says this when he wants his toy. Through simple conditioning characteristic verbal responses come to be made to the many stimulating conditions arising from internal activity. The stimulation may be either organic or kinaesthetic, and the verbal responses are often termed introspections. It is plain that a person is making verbal responses to internal stimuli just as he makes verbal responses to external ones, and yet many would hold that these responses are reports of mental experiences.

In many cases the verbalizations of an internal condition serve to enlist the co-operation of another in the removal of the maintaining tension. The popular notion that language is a means of expressing our wants is, then, not far amiss. We must,

however, be on our guard against considering these consequences a factor in the explanation of the development of verbal reactions.

THE ADJUSTIVE SIGNIFICANCE OF LANGUAGE

We have traced the manner in which particular verbal responses are developed to specific objects and occurrences, to class objects, to parts of objects and to internal activities. This development does not differ in principle from the establishment of specific manual and visceral reactions. The three developments take place simultaneously. However, in their adjustive significance the verbal responses are somewhat sharply set off from the other types. They are the means par excellence of communication, *i.e.* of stimulating others in particular ways, as well as effective means of stimulating one's self. By pronouncing the name of an object, one not only produces for others a substitute stimulus for the presence of that object but also does so for himself. Through language we carry the world of objects and occurrences around with us in substitute fashion. Through it there is an extension of our sensory range. We see and hear by means of it the happenings in the four corners of the earth. We experience what others experience through their verbalization of their experiences. What has happened in the past is still happening in language records. What will happen in the future has in our language responses already happened. What others have learned we acquire not through the long tedium of trial and error but through the records of their findings. The home, by teaching language, teaches the foundation upon which all other educational institutions build. Let us note in greater detail some of these consequences.

Language makes possible social organization just as the nervous system makes possible multicellular organizations. The meagre vocalizations of a herd of cattle are a large factor contributing to their greater success in herds. Galton in his South African travels noted in several instances that a cow with a calf stayed by herself and that no harm came to her. This did

not seem to conform to the Darwinian conception of the survival value of groups. On further observation he noticed that the cow did not graze but rather stood constantly on the alert. When she became hungry, she joined the herd where she was able to relax her vigilance and eat in safety, for, as Galton concluded, she then had not only her own sense organs but those of every member of the group. And she had these only because a frightened cry from one animal who had detected an enemy served to warn the entire herd. An excitation to one member of the herd was conducted to every member by means of sound waves produced by the response of that member, just as an excitation to one region of a multicellular organism is conducted by means of nervous impulses to the distant parts of the animal. It will be noted in this connection that as means of communicating at increasingly great distances have been devised, social groups have become larger and larger. Things happening in remote regions become a part of the immediate environment of each member of the social group. Each verbal response that is made by one who sees, hears, feels, or otherwise experiences some happening may act as a substitute stimulus for another so that in a substitute way he sees, hears, or feels the same things. We virtually have the sense organs of all whose verbal responses affect us.

Not only do we have the sense organs of others, but we also have to some extent their manual reacting systems. They have learned from manual trial and error how to adjust effectively to certain situations. Their verbalization of their own behavior guides us through similar situations. The skilled golfer may in his absence instruct us how to improve our game by describing the manner in which he plays.

Instructions may be deficient in two ways: the instructor may not have correctly described his own activities and findings, and his instructions may fail to set off the same manual response in the one instructed that he has described as taking place in himself. These possibilities of imperfection serve to re-emphasize the necessity that verbal responses be linked up to

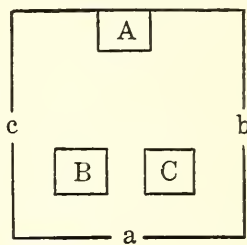
manual and visceral ones. The former type of imperfection is overcome through the fact that the rules of procedure are not the verbalizations of one man but those of many men. The rules for building apparatus, houses, bridges, roads, for making chemical analyses, for obtaining best yields from crops, and for the prevention and cure of disease are the verbalizations of the experiences of countless men of the present and past, men with the highest learning endowment. All of our industrial, governmental, and social institutions are possible only because men of high ability have made improvements and instructed others how to continue these systems.

Our educational system is an attempt to give each generation the experiences of the past, particularly those of the most successful men of the past, and also those of the present leaders. It is a distinct advantage to have these experiences incorporated into one's verbal reaction-repertoire before the situation in which the manual responses are demanded is encountered. If an individual is lost in the woods, it will be to his profit to remember that if he starts walking he will travel in a circle, and further to recall the various ways in which he may be guided out, to recall the rules that one may be guided by difference in bark on the north and south sides of trees, by obtaining directions from his watch, by following streams. When he does this, we say that he thinks before he acts, but thinking is acting in an implicit or substitutive way.

Often situations are met in which no learned verbal rule applies. If in the above case the individual were unable to differentiate the bark on the north and south side, if the sun were not shining, if he encountered an impassable gorge in attempting to follow a stream, and if he could recall no other rules to guide him, his verbal behavior would become more restless, more random. He might say to himself that he must find his way out and ask himself how he was to do it. He might abstract from all the rules he has learned the one common element, "Find something to guide you straight." He begins to look about, to observe and name objects in his surroundings, and

he tries always to make the name of each object the subject of a sentence the remainder of which is "will guide me straight." He tries trees, but the sentence is, "Trees will not guide me straight." He tries the sun, but his sentence becomes, "The sun cannot guide me, for I cannot see it." He then thinks that perhaps the sun will come out soon and so observes the clouds. At last, he has his sentence, "Clouds will guide me." We say that he has reasoned himself out of the situation, but reasoning is verbal trial and error and obviously depends upon having a number of verbal actions to put to the test. The reader is invited to try the problem below and to take note of his verbal trial and error.

A, B, and C are houses in a field enclosed by a wall. From each house a path extends to the gate that has the same letter. None of the paths cross, and of course no path runs through a house. Study the diagram until you are sure you have the solution before you draw the paths.



In a sense man's possession of a highly developed language is the outstanding distinction between him and lower animals. The thing that makes language possible is, nevertheless, not merely the structure of the vocal apparatus. One can develop language even when born with such defective laryngeal equipment as to make him dumb. The most important thing is a highly developed nervous system, easily conditioned, capable of eliciting many specific responses along with the grosser manual ones, and capable of such modification as to make these responses substitutable for manual responses.

QUESTIONS AND EXERCISES

1. It is often said that language is a means of expressing our thoughts. What would our thoughts be without language? What would the self be without language?
2. Each act has consequences whose nature depends upon the character of the act and the situation in which the act is performed. Some consequences

are relatively immediate and some relatively remote. Do you see in the recognition of this an explanation of the fact that we often do things which are immediately unpleasant? If a person is trained to act in the light of probable remote consequences, would you say that he has a high degree of self-control? Of will power? If so, what are self-control and will power, and what are their relation to language activities?

3. Discuss in detail the problem of meaning. Does the bell mean food to the trained dog? Do the objects and events related to the thing constitute its meaning? What is the relation between meaning and expectancy or anticipation? Why do we say that a parrot's talk has little meaning? In what ways does the possession of language enrich the meaning of things to us?

4. Is any bit of behavior of itself response or stimulus? Under what conditions does it become response? Stimulus? Under what conditions does a happening become cause? Effect? Discuss briefly verbal activities as stimuli and as responses.

5. Defend or attack the following statement, "Abstract words, *e.g.* gravitation, honesty, kindness, bear the same relation to activities that class names bear to objects."

6. Can you find any essential difference between reporting external conditions and internal ones? Discuss the import of your answer.

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CHAPTER 12

INTENTIONAL LEARNING

Up to this point emphasis has been placed on those manual, visceral, and verbal habits which we develop without intending to do so. Standing somewhat in contrast are those that we put on intentionally. We set out to acquire skill in shorthand, telegraphy, typewriting, foreign languages, in the operation of automobiles, lathes, looms, and in the performance of other occupational tasks with a view to employing the acquisition in the future to our own advantage. It is frequently true that one does not see the direct advantages accruing from the tasks one is engaged in learning, but even in these cases there is foresight of the indirect advantages of the acquisition and of the indirect disadvantages of failure to learn. The opinion of others, their anticipated approval or disapproval, is one of the most outstanding of these secondary incentives. The questions arise as to how foreknowledge of direct and indirect gains motivates learning and how habits that seem desirable can be most readily acquired.

THE NATURE OF INCENTIVES AND INTENTION

That the appreciation of the advantages arising from possessing certain skills or information hastens their acquisition seems almost unquestionable. Only in exceptional circumstances have we discerned any advantage in learning the number of steps in the staircases of our homes, and although we have ascended and descended countless times, we do not know how many there are. Were I to offer a hundred dollars to every reader who secures this information, all would speedily obtain it and would retain it without difficulty. The offer of a like amount to all who would memorize some obscure poem would involve the ex-

penditure of several millions of dollars. When there is available a number of positions requiring a definite set of skills, various people undertake to round out their accomplishments to include all the prerequisites. Many laboratory studies as well as casual observations show this influence of incentives. As a case in point, Bryan and Harter kept a record of the improvement of a number of telegraphers. One of them became able to receive messages with greater and greater facility until he was above the requirements for branch line operation when he secured such a position. Although he continued to receive messages, he made practically no further improvement. Then there was a vacancy on the main line for which he was eligible if he could increase his speed to meet the new requirements. This he did very readily.

In general, the greater the incentive the more rapid the learning. If I were to offer but ten cents for learning the number of steps in the staircase, many would not take the trouble to acquire the information. Those to whom ten cents means a great deal, *i.e.* for whom it represents a considerable amount of desirable consequences, would learn, and others would not. One will not put so much effort into acquiring the prerequisites for a position about which he cares little as for the one which he greatly desires. But how can the future usefulness of a habit determine that it shall be acquired and acquired rapidly? What are incentives, and how do they operate on the biological organism which we have held cannot be influenced by future stimuli?

In the third chapter of Part Two we described the animal's learning of a maze and might have said that food served as a reward or incentive. We said rather that the animal was allowed to become hungry in order to induce general activity and that food was used to terminate activity at a given point. Before a cat will learn to escape from a puzzle box, he must be hungry or frightened or stimulated by a member of the opposite sex. The mere presence of bars and knobs is not sufficient to cause him to scratch at them; there must be additional stimulation before this response is made. The mere presence of an alley or

opening is not sufficient to cause the rat to enter; both an alley and internal stimulation are required. The sight of steps is not sufficient to cause us to count them; a desire to do so must be aroused within us. Desires, as we have defined them, are internal tensions leading to heightened general activity and through training to a favoring of those responses which bring about the removal of the tension. Hunger increases general activity since it adds to the total stimulation, and it also favors the making of responses which do away with hunger. Since hunger precedes food-getting, the hunger may be said to be a desire for food, to influence behavior in the direction of food-getting.

We have already pointed out how natural wants, such as the desire for food, may be aroused by conditioned stimuli. Pets become accustomed to being fed by their keeper, and soon the sight of him makes them keenly desirous of food, as evidenced in their general restlessness.

If food is not forthcoming, if the desire is thwarted, activity becomes the more vigorous. A word or phrase in the same manner operates as a substitute stimulus. The name or thought of a delicious food makes one ready to eat, starts the flow of saliva, brings about peristaltic movements of the stomach, sets off the flow of gastric juices. When I say, "I will give you ten dollars," you become ready to spend it. How badly you want it depends upon how ready you are to dispose of it. If you are poor, you are eager to spend it in a thousand places and do, in fact, spend it verbally. The offer of money or the promise of some other reward arouses a desire, a tension, a readiness to do something. It is not something in the future that is stimulating the individual but rather a present stimulus which has its effects because of past associations. Incentives are primarily means of arousing heightened activity.

When incentives are employed to induce learning, there is also present other stimulation which directs general activity into definite channels. What the hungry rat will do depends upon the immediate external environment. The maze employed in

animal experimentation restricts his general activity to the type of action which brings the desired result. What you do when I say, "I will give you ten dollars," depends upon the conditional "if" clause which follows, and also upon the situation in which my promise is given. If it is a matter of ascertaining the number of steps in your home and I make the promise while in your home, you will count the steps immediately. If you are in the classroom when the reward is offered, you may continue with other activities and later when you arrive home you will count the steps. The promise in either case arouses not only a desire for money but also a desire to count the steps.

Some time may elapse between the arousal of a desire and its fulfillment. The fact that the stimulation is later effective is accounted for in two ways. In the first place the tensions which we call desires tend to persist and while persisting reinforce acts that lead up to the consummatory one. A case that we have already mentioned is one in point. The child is taught to make a set of responses in preparation for eating—entering the house, washing, waiting for others to be seated. After this routinary series has been acquired, hunger initiates it and causes it to be carried through to the consummatory response of eating. In the second place desires may be reinstated after they have waned. Instructions given at one time may be apparently forgotten and then carried out at a much later time. The encountering of some object or occurrence which was mentioned in the instructions serves to reinstate the original verbal response made to them. We have noted how an object and its name are practically interchangeable as stimuli. It may be that you do not reach home for several days after I have raised the question of the number of steps in your staircase, but when you are confronted by them, you suddenly recall my promise. Of practical significance in this connection is the fact that in giving instructions or suggestions the object or occurrence which is to be encountered in the course of expected routine should be mentioned first and then the act that is to be performed. Much advertising is futile because it disobeys this

principle. The parts of an advertisement should be presented in this order: the use of the article, its name, the firm from which it may be obtained. The statement, "To safeguard the complexion use English Cream Lotion," is much more likely to lead one to recall the name of the advertised product than is the statement, "Use English Cream Lotion to safeguard the complexion." In general, when suggestions or instructions are given, the parts should be presented in the order in which they are expected to operate.

We see, then, that when we learn intentionally we have been stimulated in a twofold manner, one part arousing a heightened activity or desire and the other determining that activity shall be of a definite sort. Anticipation means only that the individual is such by nature or by training that one response tends to lead to or anticipate another, as in the case of the baby who looks to his parent in the expectation of receiving a desired toy, or of the rat which enters an alley in anticipation of securing desired food. Foresight or knowledge means only that man can verbally perform a series of acts which will not be manually executed for some time. Intention refers to the foresight of our own behavior and its consequences as in the case of saying that we intend to secure theater tickets, to prepare for an examination, to avoid a crowded street car. We are certain of the performance of the act and of its consequences in the same way in which an astronomer is assured that an eclipse will take place. We have observed in our own past behavior and in that of those about us that one set of acts leads to others and that each act has its consequences. As far as we know, man is the only organism whose behavior is influenced by intentions and foresight, and in these abilities he possesses a distinct advantage, for they enable him to live not from day to day but in conformity to an extended plan. What is done today he perceives as an act having not only immediate but also temporally distant consequences. If the consequences are unwelcome, their verbal presence sets off manual avoidance; if they are advantageous, their verbal presence acts as a general reinforcement

to carrying out the set of acts manually. The consequences which in reality ensue in the future exist substitutively in the present and have practically the same effects as if they were actually at hand.

From the above it is clear that there is a very close relation between intentional and non-intentional learning. This similarity becomes more apparent when we recall that a stimulus becomes substitutable only when the response to which it is being attached is the dominant one or a component of the dominant one. Pavlov uses hungry dogs to make sure that the salivary secretion will be a component of the dominant activity. If the dog's taste bulbs are stimulated with acid, the saliva flows in much the same manner as when they are stimulated with food, but conditioning either fails to take place or is established much less readily. To insure conditioning, it is not enough that a reaction is made; it must be vigorous and a part of the dominant behavior pattern. It is obvious that one may practice typing and yet be doing something else much more vigorously. Under these circumstances no improvement would be expected if the findings in the study of simple conditioning are valid. To insure dominance and hence improvement the individual is motivated by giving him an insight into the consequences of his behavior and by employing other incentives which arouse within him a strong desire to learn typing. We derive no benefit from half-hearted practice of any sort. Incentives are the means of inducing a whole-heartedness. On the other hand a desire that does not issue in definite action is without value. Pathetic are the cases in which desire is strong but the guidance of activity into definite channels is lacking. Undirected ambition is as unavailing as dispirited activity.

COMPLEXITY OF INTENTIONALLY ACQUIRED HABITS

Most of the habits which we intentionally take on are complex. In them we use not only our hands but also our heads, *i.e.* manual habits in adults are inextricably interwoven with

verbal ones. Typewriting is not simply movements of the fingers but these movements as they are linked up with letters and words, either seen, heard, or subvocally spoken. The word seen or heard issues in the subvocal saying of the word, and this implicit verbal response precedes and guides the finger movements.¹ The novice subvocally pronounces each letter, and then some time intervenes before the proper key is struck. This period is consumed in verbally locating the key if the individual is learning by the touch method and in casting the eyes over the keyboard until the proper letter is seen if he is employing the sight method. These seeking movements may be analyzed in a way almost identical with that in which the seeking movements of the baby who has heard the name of a toy were analyzed. (See pages 178 f.) With time the seeking movements in typing drop out, since the subvocally spoken name of a letter is always followed by a particular finger movement. Each letter as it is thought has come to act as a conditioned stimulus for eliciting a specific manual response. After further practice another improvement also takes place. The individual no longer implicitly pronounces each letter, but rather only syllables or entire words. One finger movement has often followed another so that the kinaesthetic stimuli tend to set off the succeeding movement, but this kinaesthetic stimulation is not of itself sufficient. The letter "t" is sometimes followed by one letter and sometimes by another. When "the" is to be written it is followed by "h," and the implicit pronunciation of "the" together with the kinaesthetic stimuli from striking "t" sets off the striking of "h," *i.e.* the writing of a word is a serial habit dependent upon response-derived stimuli and upon a specific set of subvocally-derived stimuli. The serial response of suckling is determined in a like manner, by response-derived stimuli and by organically-derived stimuli.

Kinaesthetic or response-derived stimuli play a large rôle in other complex habits. We have previously mentioned the fact

¹ See Rexroad, C. N., "Verbalization in Multiple Choice Reactions," *Psychological Review*, 1926, 33, pp. 451-458.

that a rat, after having learned a maze, runs through the series of turns even though all external receptors have been anesthetized or removed. A poem which we have committed to memory is a serial habit, one word through its kinaesthetic stimuli giving rise to the next. If these stimuli fail to elicit the succeeding word, if we forget at some point, we repeat in the expectation that with the repetition the kinaesthetic stimuli will be effective.

IMPROVEMENT CURVES

When a record of the proficiency in the execution of complex tasks is kept and the results plotted, it is usually found that there is an initial rapid improvement and then a gradual falling

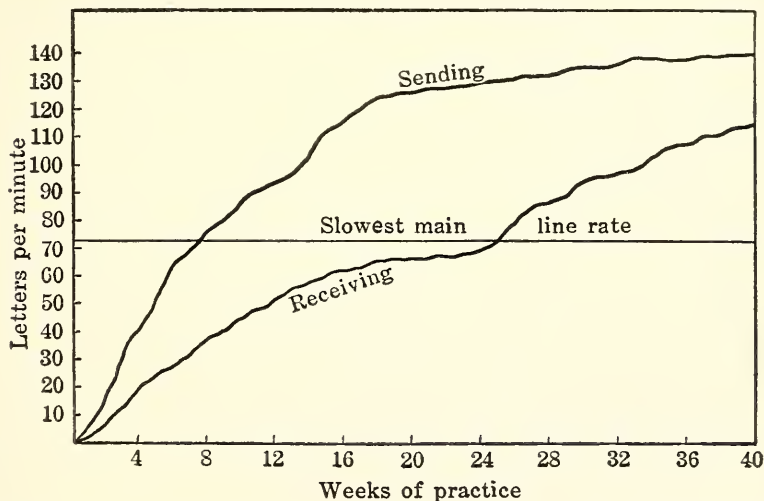


FIG. 23.—Practice curve of student W. J. R. in learning telegraphy.
(After Bryan and Harter.)

off in the rate until eventually no further progress is shown. One of the curves obtained by Bryan and Harter is a case in point. (See Figure 23.)

In this record the number of letters per minute is taken as a measure of efficiency. This is the practical measure for telegraphers, but in many cases there is an advantage in keeping the record in terms of the length of time required to do a certain

task rather than the amount of work that can be done in a given time. With this form of record each practice period is more nearly comparable with every other, for the individual makes the same number of correct movements in all periods. Had Bryan and Harter used this method their curve would have been inverted; a drop rather than a rise would indicate improvement.

In some cases efficiency is to be measured by accuracy rather than by amount or speed. Improvement in archery and rifle shooting must almost necessarily be measured in this manner. A plot of improvement in archery taken from a study by Lashley is shown in Figure 24.

In many tasks both speed and accuracy are important, and usually improvement in both is shown. Sometimes the data are

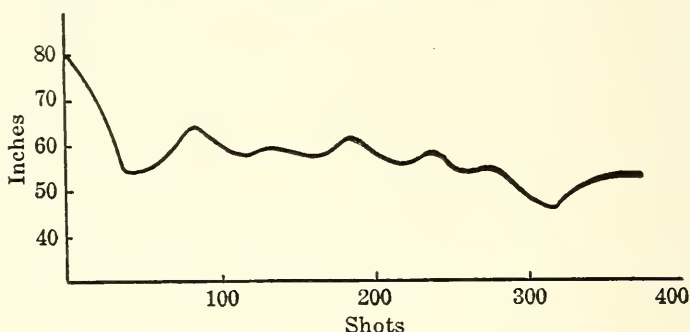


FIG. 24.—Improvement in archery. (After Lashley.)

plotted separately and sometimes combined in a single plot by making a deduction for each mistake. Improvement is more marked in speed if speed is emphasized in motivating the individual and more marked in accuracy if accuracy is required. In practical situations a margin of inaccuracy is often allowed, and the individual keeps within this margin at the sacrifice of speed. Most stenographers make a few minor errors and have done so throughout their training and experience. As long as these are excused, there is no gain in accuracy.

It will be noted that the rate of improvement in archery is quite different from that in telegraphy. In fact, the plot for each

task shows a characteristic curvature. A large proportion of improvement curves is characterized by the initial greater rapidity of rise or fall, and it is this which is implied when *the* learning curve is mentioned. The commonness of this characteristic has led to the formulation of a law which is called the law of diminishing returns, that the greater the practice on a given task the less the returns in improvement. It will be noted, however, that the law does not state that the returns from the standpoint of retention diminish. If a typist were to cease practice at the time she had reached approximately her maximum speed and then return to her typewriter several years later, there would be considerable loss. If however, she had overlearned her task, had practiced beyond this point for a prolonged period, the loss during the period of no-practice would not be so great. A large number of our habits, such as swimming, playing tennis, typewriting, playing the piano, writing, are overlearned and suffer little from disuse. If we memorized a poem to the point of being just able to repeat it immediately, approximately half the number of repetitions involved in learning would be required for relearning the next day. For every three repetitions beyond this point, one repetition in the relearning process twenty-four hours later is eliminated. If we continued our practice long enough, the poem would be retained for several days or even years. Extended practice, then, does not fail to bring returns; it merely ceases to bring improvement in accuracy and speed.

Some plots of improvement do not show this initial rapid rise. Rather there is prolonged practice before any improvement is noted, then improvement commences, and from this point it follows much the same progress as in those cases where it begins immediately. This type of curve is the one which depicts the improvement in puzzle solution. A plot of this sort is shown in Figure 25. Had practice continued beyond the point indicated in the plot, there would have been little further improvement because of the physiological limits of speed. Such curves are also often found in animal learning. Koehler found many

instances of it in his experiments with apes. These curves present an interesting and baffling problem to students of behavior. Let us see how adequate an explanation can be offered for them.

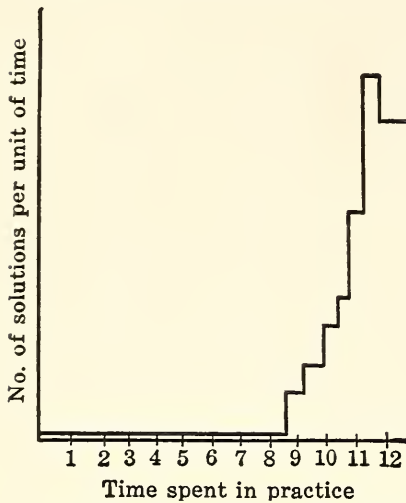


FIG. 25.—Improvement of Rd. with a certain puzzle. (After Thorndike.)

INSIGHT AND LEARNING

Presented with a puzzle, we make both manual and verbal responses of a trial and error sort. In the course of the manual movements which ordinarily are verbally directed, we happen upon the solution without realizing just what the essential steps are. Perhaps on several succeeding trials the solution comes in this manner. Eventually we see the steps or principles involved

and on succeeding trials solve the puzzle without difficulty. This ability to see the necessary relations involved in the successful performance of the task is called insight. The analysis of this ability is our next concern.

In the case of puzzle solution a person eventually finds a rule. Suppose he undertook to solve the puzzle which is diagrammed in Figure 26. There are three pegs, and on one of them six wooden discs of varying circumferences, arranged in the order of size with the smallest on top. The task is to transfer all the discs to another peg, never removing more than one at a time and never placing a large one on top of a small one. At first the individual moves the discs in haphazard fashion and eventually succeeds in transferring them. As he proceeds with other trials, he learns to define his immediate problem at various stages of his task. Suppose he has a and b on peg 2 and c on peg 3. In order to remove d, he must place a and b on c. To do this he puts a on 1 and b on 3 and then a on 3. Here he has two

discs (a and b) to move, and he has placed the first one on the peg on which he does not want the two. As he continues, he evolves two rules which will fit all cases. (1) When there is an even number of discs to be moved, place the first one on the peg other than the one on which the group is to go. (2) When there is an odd number, place the first one on the peg on which the group is to go. How did he arrive at these rules? We find from his reports that he is making many verbal responses from the beginning, that he is substitutively moving the blocks with his language equipment and noting verbally the consequences

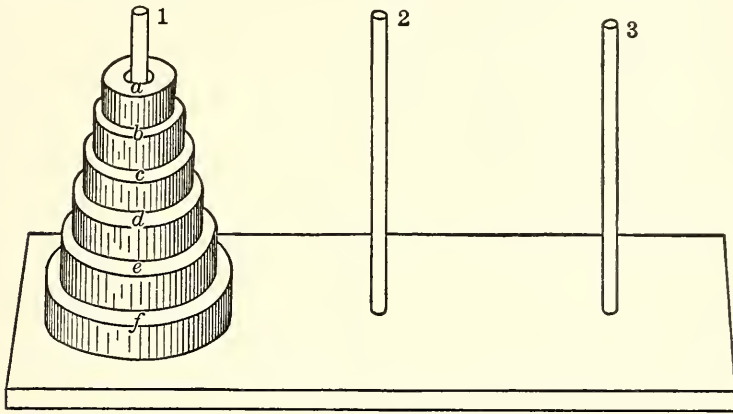


FIG. 26.—Three-peg puzzle. Explanation in the text.

of each move. When he makes a move that brings him nearer solution, he repeats it verbally, *i.e.* defines in some way where the various discs were and the peg to which movement was made. At first he may subvocally state the position of the discs by merely noting the number on each peg irrespective of their size, or by noting the relative circumferences of the two upper ones, and he may refer to the pegs as 1, 2, and 3, or as right, center, and left. These verbalizations do not serve to guide his overt movements effectively, and so he continues to make verbal responses until he arrives at helpful ones. In short, he has been reacting with many learned verbal responses to various characteristics of the stimulating condition and to his own movements, and eventually verbalizations of such a type

result that he experiences no further difficulty in overtly performing the task. He comes to react to those elements of the situation which contribute to his success.

Animals do the same thing except that their trial and error responses are manual instead of predominantly verbal. Suppose, for example, that a monkey is confined in a cage and that there are bananas within sight but just beyond his grasp. The usual response to this stimulation is made; he attempts to reach the bananas. After many unsuccessful trials he changes his form of response, climbs up the side of the cage, shakes the bars, runs frantically about. If a stick is near, he may pick it up and in the course of the movements made with it in his hand may touch the bananas and eventually draw them within reach. This performance does not evidence any insight, but if on several occasions he secures bananas with the aid of a stick and later seeks a stick when there is none in sight, he may be said to show insight, to understand that a stick is necessary in obtaining bananas. The stimulation of bananas out of reach leads now not to direct approach but rather to the preparatory act of obtaining a stick.

This transition in which the random movements drop out of the monkey's behavior and the random verbalizations from man's responses seems adequately explained in terms of conditioned reflex principles. It is learning through trial and error. It differs from maze learning as analyzed in Chapter 8 in that a manipulatory response is demanded rather than the traversing of an open route. The nature of the manipulatory act is discovered through trial and error, as in the case of the cat's learning to pull down a lever. After the organism has learned from experience what indirect or preparatory reactions to make, insight is said to be involved. Before this stage is reached, we speak of perplexity. It is obvious that both terms are descriptive of behavior and are not explanatory.

We may note another difference from habits previously described as established through trial and error. If the stimuli to which the preparatory reactions are customarily made are

absent, the organism with insight seeks them. The monkey, after he has learned to obtain bananas with a stick, looks about until he finds a stick. The person experienced in puzzle solution seeks clues to aid in solving the somewhat novel puzzle, *i.e.* the organism uses past experience in situations which are partly new. His behavior is not merely haphazard, not a reaction to any part of the situation, but is a definite seeking, a disregarding of many elements and a persistence in casting about until an element which has been used in similar situations is located. This characteristic is accounted for in much the same manner as was the definite seeking by the infant of a toy whose name has been spoken. (See pages 178 f.) That behavior was explained in terms of a selective tension substitutively induced by the name of the toy. The ape's seeking for a stick may be likewise accounted for in terms of a selective tension set up by the sight of the bananas out of reach. He has repeatedly seen them and has then manipulated a stick. The sight of the bananas comes to tend to set off these manipulatory movements, but in the absence of the stick the movements remain incipient. These implicit movements or muscular tensions together with the neural changes involved favor overt reactions to a stick and make less likely responses to other objects.

It is obvious from the foregoing that the appropriateness of acts in a baffling situation depends upon previous experience. Shaking the bars is of no advantage to the ape in securing bananas, while securing a stick has proved helpful. The pertinency of verbal responses in solving a puzzle depends upon past experience with puzzles. The value of the verbal responses made when one is lost in a wood depends upon the rules one has been taught to cover situations of this sort. When one makes a number of fairly relevant verbal responses and finally comes to a correct one, we refer to his activity as reasoning. When an ape makes a number of appropriate responses and finally the successful one, should we not also say that he reasons?

When one through a series of pertinent responses gains an

insight into a situation or task, the time required for completing that task is suddenly greatly shortened. Before this time the task has been done differently each time while afterward it is done in the same manner on each trial, and the time required is thereafter gradually reduced through the repeated performance of the series of reactions. This accounts for the type of improvement plot last mentioned.

FACTORS INFLUENCING THE RATE OF IMPROVEMENT

Up to this point we have been concerned mainly with the analysis of intentional learning, showing that there are no new fundamental principles necessary to its explanation. It is learning influenced by stimulation to which direct response cannot be made. The ape in the experimental situation cannot go directly to the bananas, just as we cannot earn money by typing until we learn to type or procure food without planting or purchasing it. In the case of the human the goal of our quest does not have to be visually present but only the promise of it, for to us an object and its name are largely interchangeable as stimuli. We may now turn to the more practical side and inquire concerning the factors that influence the rate of acquisition.

A. The Nature of the Task.

This element we have already discussed sufficiently. One task is learned much more readily than another.

B. The Length of the Task.

When one sets out to learn a long poem, a long series of nonsense syllables or any other material in which the task is divisible into parts of comparable difficulty, it would seem at first thought that proportionately more time is required than for shorter tasks of the same nature. Experiments, however, show that this is not the case. The plot of Figure 27 showing the time required to learn lists of nonsense syllables indicates that the time required is directly proportional to the length of the series.

C. The Amount of Previous Practice.

In connection with the law of diminishing returns we discussed the effects of previous practice on the task itself. There is also an effect accruing from having practiced similar tasks. The advantage derived in this manner is termed transfer of training. At one time it was thought that a great amount of transfer from one task to another takes place, but experimentation has revealed that it takes place only to the extent that there

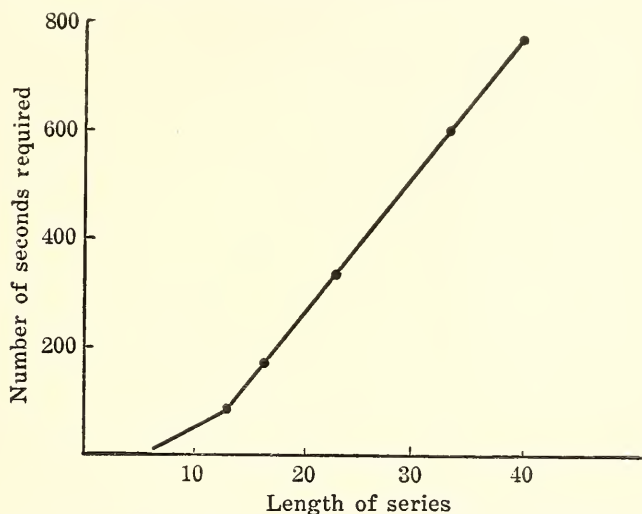


FIG. 27.—Showing the direct relation between the length of series of non-sense syllables and the time required for memorizing them. (After Smith and Guthrie.)

are identical elements in the tasks. Mastery of Latin lends practically no help to mathematics while it helps in English vocabulary only to the extent that English words are derived from Latin roots. Practice on the piano helps in typing only in so far as it has developed flexibility of finger control. Ability to solve mathematical problems does not produce ability to solve other sorts of problems except in case the same rules of procedure may be followed. Activities are specific, and there is transfer only to the extent that several activities involve the same components. In many cases the same procedure is com-

mon to several tasks and most probably the method of procedure learned in one task transfers to another.

D. Previously Acquired Conflicting Habits.

Previous experience sometimes interferes with new acquisitions. After one has learned to type on a standard keyboard, one will experience great difficulty in using a different sort. If one has developed one's own style of playing golf, it is more difficult to learn good form than it would have been without experience. It is hard for an adult to learn new things simply because he possesses well-established habits. This is at the basis of the adage, "Strike while the iron is hot."

At one time the theory that instincts ripen and then fade was proposed to account for the inability to learn when older what would have been easy to learn at an early age. True enough, instincts ripen or, as we have expressed it, abilities develop as maturation proceeds, but there is no evidence of their fading. An illustration from animal behavior will make this clear. Chicks without training follow any moving object. Under normal conditions this is the mother hen. If they are raised in a brooder, they come to follow the person who tends them and to disregard a hen. They have developed a specific response from the more generalized unlearned one; and having developed this, it is almost impossible to re-train them, whereas it would have been easy to teach them to follow a hen in the first place. Desired habits should be acquired before incompatible ones have been established, not when some mysterious instinct is supposedly ripe.

E. Distribution of Practice.

A fifth factor that influences the rate of improvement is the distribution of practice. In most cases the improvement per trial is greater when the trials follow each other at long intervals. Least time will have to be devoted to memorizing a poem when it is repeated but once each day, more time when repeated twice each day, and most time when gone over at one

sitting until learned. The results in an experiment by Yost may be cited as fairly typical:

	<i>Score on test Mr. M.</i>	<i>Score on test Mr. B.</i>
8 readings a day for 3 days	7	18
6 readings a day for 4 days	31	39
2 readings a day for 12 days	55	53

It is possible that in some cases the individual practices implicitly in the intervening period, yet it is found that rats learn a maze in fewer trials when the trials are spaced rather than given in quick succession. A difficulty in the practical use of the spaced method is the fact that a tremendous waste of time is involved in passing from one task to another. It is true, too, that some tasks require what is often called a warming-up period whose length may be materially reduced if habits with reference to time and place of work are formed.

F. Strength of Incentives.

The nature of incentives and the manner in which they influence the rate of acquisitions have been discussed. The practical problem, particularly in our educational system, is to find these incentives which motivate the desirable habits. It is difficult to give the uninitiated an insight into the value of some accomplishments. It is not easy to convince a youth that his life will be enriched by learning to produce and appreciate good music and by studying many of the subjects in the arts curriculum. Nevertheless, those who are conversant with these subjects are convinced that they are worth while. As a consequence the pupil is motivated by secondary considerations—the opinion of the more experienced, the hope of gaining social prestige, competition with his fellow classmates or his own record, and perhaps also the winning of prizes or other marks of distinction. The possibility of excelling is an incentive that may be employed to actuate the learning of almost any sort of task.

G. Methods.

1. *Whole versus part method.* Any incentive is likely to lose its force unless the individual has the concrete testimony of

visible accomplishment. For this reason most of us break up our long tasks into several shorter ones. We can memorize a stanza of a poem in a short time, and having accomplished this we can see that a certain portion of our task is done. If we were to attempt to memorize it as a whole, we should spend some time before any visible results appeared, but it is found that we learn with fewer repetitions or in less time if we take the poem as a whole. An experiment by Pyle and Snyder gave the following results as the average time for a group memorizing by the two methods:

431 minutes learning 30 lines at a time.

348 minutes learning as a whole.

It may be said, then, that the whole method is more economical while the part method has the advantage of visible accomplishment.

2. *Repetition versus recitation.* In memorizing (verbal learning) it is also advantageous to proceed as fully as possible without the copy before one, *i.e.* to recite to one's self, prompting one's self only when necessary. In many school subjects a large amount of rote memory is required. In these cases the recitation method is especially to be recommended. One concrete form is useful when a number of paired items such as the names of chemicals and their formulae or the English word and its equivalent in a foreign language are to be learned. Place one item of the pair on one side of a small card and the other on the reverse side. Pick up the cards seriatim, and when you succeed in giving from looking at one side the item on the other, put this card aside; when you fail, glance at the back of the card. Occasionally test your memory of the cards that have been put aside.

3. *Time spent in analysis and association.* Practically all advertised memory devices are schemes to aid in the formulation of associations. It is generally recognized that the greater the number of associations formed the greater the probability of recalling the item. Someone may exhibit a seemingly remark-

able memory by repeating a list of fifty words after they have been read to him slowly and distinctly. Usually this is done by having a list already well learned and then as each word is read an association is made between it and the word in the memorized list. It may also be done by making associations between each word and the one following it. For example, these non-sense, syllables—wak, pam, zut, hep, beg, ron, taz, vis, lub, mer, koj, yad—may be memorized by connecting them into a somewhat meaningful sentence, *wakpam's hut had a heap big rontaz visible to the lubber from his back yard*. These devices are for the most part impracticable, for the type of material to which they are applicable is seldom met. Furthermore, experiment shows that the time taken to make such associations is usually greater than the time required for straight memorizing. On the other hand, many items have meaning only as they are associated with others. A person's name has meaning only as it is associated with his appearance, his mannerisms, facts in his history, and is remembered only when these associations are made. The material of a textbook is remembered only when one notes the relationship of the parts and their bearing on the whole. We might conclude, then, that it is worth while to seek all the associations that are an integral part of the material to be learned but not worth while to spend effort in reading associations into the material.

In the acquisition of a manual skill, it is obviously advantageous to make an analysis in order to find what activities are interfering with progress and just what are essential to best accomplishment. Books on Industrial Psychology are replete with instances in which this sort of analysis has lessened the time required for learning and has resulted in a more economical performance after the level of proficiency has been reached.

ECONOMY IN STUDY

Study involves more than memorizing; it is the ascertainment of the answers to certain questions and then the fixing or memorizing of these. Three phases are embraced: (1) gaining

a conception of the problems dealt with in the assignment, (2) finding the solutions offered, and (3) fixing these in memory.

Little more need be said with reference to economy than that these phases should be mastered in order. If the instructor has not given a conception of the problems to be taken up in the assignment, the student should secure this either by perusal or a rapid reading. A person cannot answer a question until he knows what it is, and he cannot organize material until he is acquainted with the salient points upon which to base his organization. Often topic headings are given in the text and these become the major topics in the outline if an outline method of organization is used. Some students find it advantageous to transform the topic headings into questions, *e.g.* "Factors influencing the rate of learning" becomes, "What influences the rate of learning?" After a list of questions or main topics is made, the student begins the second phase of study, namely seeking the answers to the questions or listing the items subsumed under the main topics. In doing this, he may find it necessary to add sub-questions or sub-topics. After the material has been related in an outline or after the answers to the questions have been found, it remains only to recite the material to one's self until it is sufficiently firmly established. If the assignment is easy, all these phases may be mastered in a single careful reading, and in difficult assignments little time will be required for the third phase, for it is found that material that is understood or is meaningful requires little rote memorizing.

The following rules may then be given for study of assignments of average difficulty:

- (1) Gain a general conception of the problems considered, either by glancing at the topic headings, by reading the summary, or by a rapid reading of the whole.

- (2) Pick out the main topics or the salient questions.

(3) Organize the material in outline form or in the form of answers to questions.

(4) Determine by recitation to yourself that you can give the points bearing upon any topic or the answers to any question.

QUESTIONS AND EXERCISES

1. Make a list of incentives. Do you mean by an incentive a promise, explicit or implied, or the effects on the person of a promise?

2. Do animals intend to do the things they do? What do you mean by "intend"? Discuss intention in relation to expectancy, desire, and premeditation.

3. Discuss improvement in complex tasks in relation to elimination of useless movements and in relation to the formation of serial habits.

4. Suppose a person were given the task of learning a maze on the plan of the Hampton Court maze (Figure 21). What would be the advantages of his being able to verbalize his own activity while in the maze? Could a person be taught such a maze before he entered it? If so, how is this made possible? Suppose a person sets out to learn golf. Are there advantages in being able to verbalize one's own activity while practicing? Could a person be taught to play golf before taking a golf club in his hand? If not, why? In learning any complex habit what are the advantages of being able to verbalize the situation, one's own activity, and the results of that activity?

5. In learning new problems why is behavior not wholly random? What is a *new* problem?

6. Do you think that in the learning of vocational tasks there is at present any great amount of wasted effort? What, in your opinion, would be necessary for the elimination of waste in the learning of specific tasks?

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PART THREE

CHARACTERISTICS OF ADULT BEHAVIOR

CHAPTER 13

COMMON ACCOMPLISHMENTS AND METHODS OF ACCOMPLISHING

Although each person, through variations in inheritance and environment, has an individuality which sets him off as distinct from all other persons, yet in structure, actions, and accomplishments we are after all markedly alike. In considering the characteristics of adult behavior, we shall treat first the common possessions and then individual differences. We shall deal with the former in the first four chapters of Part Three and with the latter in the three chapters on Individual Differences, Intelligence, and Personality.

COMMON ACCOMPLISHMENTS (INSTINCTS)

Perhaps the most outstanding fact, when we consider the common features of man, is that all of us achieve similar ends with more or less success. The achievements most frequently mentioned by students of behavior and the most inclusive are self-preservation and race-preservation. In order that these greater ends may be attained, lesser ones must be achieved. Food must be procured, shelter obtained, reproduction insured, the young protected, enemies conquered, co-operation undertaken. It might be well to note again Watson's classification of unlearned responses given on pages 138 f. All men, except the small percentage of highly deficient, accomplish these ends.

In contrast to the uniformity of method followed by the members of any infra-human species is the variation in method from one person, tribe, nation, or social level to another. The sort of food obtained and the method of procuring it varies from individual to individual, but food of some sort sufficient for sustenance is obtained. The sort of shelter erected, the manner of protecting one's self from the elements may likewise

differ widely from one locality or time to another, but each person has a spot that for him is home, a thatched or adobe hut, a cave, a wigwam, a house of ice, a log cabin, a cranny, or a mansion. Mating may take place under widely different marriage customs, but marriage in one form or another is prevalent the world over. The amount and kind of protection and direction given a child by its elders is determined by the mores of the elders. The manner of fighting may vary from the use of the bare hands to the methods employed in modern warfare. Co-operation may vary in complexity from the simple union of blood relatives in a tribe to the intricate associations in modern society, but wherever men are found, they have friends and helpers; they are interdependent.

In seeking the explanation of the fact that men universally engage in activities leading to these results, many psychologists and sociologists have committed what seems to the author a grave fallacy. They postulate an instinct to account for each accomplishment. We often hear of the two all-inclusive instincts—self-preservation and race-preservation—and of the lesser instincts—the food-getting instinct, the instinct of habitation, the mating instinct, the maternal instinct, the instincts of fighting and fleeing, and the gregarious instinct. Since under some circumstances food must be hunted and stored, we hear also of the instincts of hunting, acquisition, and hoarding. Since in co-operation, there is submission and dominance, instincts of submission and dominance have been held to exist. The fallacy is one of tautology. When one says that there is a food-getting instinct, all that is said is that men get food. When one says that there is an instinct of race-preservation, all that is said is that the race persists.

The word "instinct" may have a certain amount of descriptive value, for in speaking of the motherly instinct, one describes in a shorthand fashion a great deal of behavior displayed by a large percentage of women. Because of their descriptive value, we shall include the list of instincts given by Thorndike ¹

¹ "The Original Nature of Man," *Educational Psychology*, Vol. 1.

and a similar one given by Warren.² These may well be viewed as schemes of classifying the common modes of behavior. There are forty-two instinctive reactions in Thorndike's list:

I. Food-getting and protective responses.

1. Eating.
2. Reaching, grasping, and putting objects into the mouth.
3. Acquisition and possession.
4. Hunting.
5. Collecting and hoarding.
6. Avoidance and repulsion.
7. Rivalry and co-operation.
8. Habitation.
9. Response to confinement.
10. Migration and domesticity.
11. Fear.
12. Fighting.
13. Anger.

II. Responses to behavior of other human beings.

14. Motherly behavior.
15. Gregariousness.
16. Responses of attention to other human beings.
17. Attention-getting.
18. Responses to approving and to scornful behavior.
19. Responses by approving and scorning behavior.
20. Mastering and submissive behavior.
21. Display.
22. Shyness.
23. Self-conscious behavior.
24. Sex behavior.
25. Secretiveness.
26. Rivalry.
27. Co-operation.
28. Suggestibility and opposition.
29. Envious and jealous behavior.
30. Greed.
31. Ownership.
32. Kindliness.
33. Teasing, tormenting, and bullying.
34. Imitation.

² *Elements of Human Psychology.*

III. Minor bodily movements and cerebral function.

- 35. Vocalizations.
- 36. Visual exploration.
- 37. Manipulation.
- 38. Cleanliness.
- 39. Curiosity.
- 40. Multiform mental activities.
- 41. Multiform physical activities.
- 42. Play.

Warren's list is in many ways similar, the manner of grouping the various instinctive activities being markedly different:

- | | |
|-------------------------------|----------------------------|
| 1. Nutritive (instincts). | 2. Reproductive. |
| Walking. | Mating (sexual attraction, |
| Feeding. | courtship). |
| Wandering [hunting]. | Maternal. |
| Acquiring [hoarding]. | Filial (of infancy). |
| Cleanliness. | |
| Diffused expression. | |
| 3. Defensive. | 4. Aggressive. |
| Fighting. | Fighting. |
| Submission. | Resenting. |
| Hiding. | Domineering. |
| Avoiding. | Rivalry. |
| Modesty [shyness]. | |
| Clothing [covering]. | |
| Constructing [home-making]. | |
| 5. Social. | 6. Individual development. |
| Family (parental and filial). | Imitateness. |
| Tribal [herding]. | Playfulness. |
| 'Apothetic.' | Curiosity. |
| Sympathetic. | Dextrality (right-handed- |
| Antipathetic. | ness). |
| Co-operative. | Communicativeness. |
| | Esthetic expression. |

[NOTE: Names in square brackets denote a more primitive form of the same instinct.]

Once a common mode of behavior has been termed an instinct, it is generally conceived as being a result of heredity.

That there is a large element of learning which enters into each seems indisputable. Our food-getting activities are without question predominantly learned. Even though an act is unlearned, it should not be referred to inheritance alone since from the time of conception the nature of the individual is being determined by both the nature of the germ plasm and the character of the environment in which he develops. We enlarged upon this statement in Part One to such an extent that it seems unnecessary to reiterate.

Furthermore, the use of the word instinct leads one to think of non-physical forces, of hidden dynamic urges residing somewhere within us. The postulation of such forces is animism. To primitive man all action, that of both animate and inanimate things, was explained in terms of hidden spirits, good or evil. If a rock fell from a cliff and struck a companion, the falling was caused by an evil spirit within the rock. A spring of water was caused to flow by the will of a good spirit. Vegetation was made to grow by the goddess of vegetation. Thunder was the angry voice of a god hidden within the storm; lightning was the flash of his sword, the glare of his chariot, or the gleam of his eyes; and the wind was his breath expelled vehemently in anger. All objects and events were conceived as personal, as having hidden spirits or persons within them. These hidden controls of action were assumed to be different in nature from things which could be seen, were considered non-physical or spiritual. This animistic viewpoint was carried over into the actions of men. Insanity was regarded as the possession by demons, dreams as the wandering of the inner man, stoicism as the result of the residence within man of the spirits of rocks, cunning as the contribution of the spirit of foxes. Each mode of action was conceived as being caused by a spirit, and in the sixteenth century A.D. man was regarded as housing some sixty or more hidden men, or faculties as they were then called. There were faculties of reasoning, observation, kindness. In time each hidden spirit or faculty was assigned a location within the body. We still speak of the heart as the seat of love. As physiology

began to understand the true function of the bodily organs, the faculties were shifted in location to some part whose function was still a mystery. Eventually most faculties were assigned a location in the head. To read character, it was by assumption only necessary to determine the contour of the skull. Prominence of the forehead indicated profound ability to reason. Any protuberance of the skull was a sign of the possession to a marked degree of the faculty assumedly located under the protuberance. Cranioscopy was developed by phrenologists and is based upon a fundamental misconception of the function of the brain, a misconception resulting from the animistic assumption of faculties. When instincts are conceived as hidden dynamic, non-physical urges, the same line of reasoning is pursued. Each faculty was regarded as the determinant of a characteristic trait, and each instinct, when conceived as an urge, is considered the cause of a common mode of action. Primitive man knew no more about the cause of vegetative growth after attributing it to the goddess of vegetation than before, and one gains no insight into the cause of maternal behavior by ascribing it to a maternal instinct. To primitive man the observable fact was that vegetation grows, and to the student of behavior the observable fact is that men through their actions achieve common goals. The plant physiologist finds in the structure of the plant and the surroundings in which it lives the causes of its growth; the physicist finds in the nature of the rock and its relation to the earth the cause of its falling; and the psychologist, if our reasoning is valid, finds in the structure of man and in the nature of his environment the causes of behavior universally shared. That which is hidden from unaided sight is not different in fundamental nature from that which is seen, but rather it is of finer texture and is to some extent a matter of relationships. Faculty psychology made a contribution, not in explaining behavior but rather in classifying it, and the doctrine of instincts makes a similar contribution.

Lest the statement that a common mode of action is explained

in terms of common organismic structure and common environment be thought too general, we shall be more specific. We all protect ourselves from burns because we have pain receptors neurally linked with our muscles and because we encounter noxious stimuli. The presence of stimulation and the possession of stimulus-response mechanisms of a physical sort are responsible for our retraction, not a non-physical instinct of self-preservation or protection. Our withdrawal has preservation as its consequence, not as its cause. Mating takes place the world over because all persons have reproductive organs neurally linked with their receptive system and because each person encounters an individual of the opposite sex, encounters an unconditioned stimulus for evoking definite mating activities, not because there is an instinct of reproduction or race-preservation. Anger is universally exhibited because we all possess adrenal glands into which nervous impulses are delivered when we encounter the obstructions which all of us are certain to meet, not because we possess an instinct of anger or pugnacity.

METHODS OF ACCOMPLISHING (INTELLECTUAL FACULTIES)

Behavior may be advantageously described in another manner. Men exhibit various ways of meeting the situations of life. A problem is attacked with more or less persistence, more or less open-mindedness, more or less concentration. These procedures may be exhibited in meeting the problems of procuring food, those of obtaining shelter, or those of securing a mate. Instead of characterizing an act by its end-result as in the previous section, we are here characterizing it by the abstract features attached to it. Chapman and Counts give a list of the most desirable procedures, those to be especially fostered in our educational systems:³

1. Habit of inquiry; the tendency to seek problems and explanations.
2. Habit of concentration; the tendency to concentrate all the available intellectual energy on a problem.

³ *Principles of Education*, page 389.

3. Habit of persistence; the tendency to work on a problem even though its solution is difficult and brings no immediate reward.
4. Habit of reference; the tendency to consult reliable authorities even though such consultation delays solution.
5. Habit of open-mindedness; the tendency to discount prejudice.
6. Habit of integrity; the tendency to watch for, and avoid, illicit "rationalization."
7. Habit of disavowal; the tendency to be willing to acknowledge one's ignorance whenever and wherever it exists.
8. Habit of demonstration; the tendency to differentiate desire, belief, and proof.
9. Habit of analysis; the tendency to reduce an experiment to its component parts.
10. Habit of generalization; the tendency to reduce a series of experiences to a general principle.
11. Habit of application; the tendency to use general principles in later experience.
12. Habit of self-reliance; the tendency to rely on one's own judgment and mental processes.

No matter who the person and what the problem, these ways of attacking the situations of life are exhibited to a greater or lesser extent. As methods of attack they are shared universally but in differing degrees. Each habit is the result not of some hidden psychical power but of an integrated physiological organism which is what it is because of nature and nurture.

Each word employed in designating the mode of attack is an abstraction coming into existence in the manner discussed in Chapter 10. A person in attacking one problem continues in the face of difficulties, in meeting another situation he perseveres to the end, and at still another time he persists at a task which others have abandoned. There may not have been a single act common to all three cases, but in all he was persistent. This one feature is singled out in essentially the same manner as the features common to all chairs are abstracted from the variable ones. Just as an abstract chair has no existence, so persistence does not exist. There are specific chairs, and there are acts

characterized by persistence. Inquisitiveness or curiosity does not exist but only behavior which leads to discovery.

These procedures are often referred to in literature and popularly as intellectual powers or faculties. This manner of reference is convenient but somewhat misleading. After we have observed that a person perseveres in a number of situations, we are fairly safe in predicting that he will persevere in others. There is something within him which cannot be seen and which is not being displayed at all times. It is convenient to have a name for this "something." To say that it is neural modifications which have been produced by training and which cause him to persevere when occasion demands is cumbersome, while to say that he possesses perseverance is concise and legitimate if we mean only that his sensori-neural-motor equipment possesses characteristics which are responsible for his way of acting. The danger is that we may, when perseverance is mentioned, think of an entity, a force, a hidden spirit, as did Faculty Psychologists. Furthermore, when a procedure is mentioned, we should not expect to find the neural modifications responsible for it located in some definite region of the nervous system as did the later phrenologists. The nervous system functions as a whole, a unit.

It is obvious that to list all the intellectual powers and all the instincts or desires commonly shared, that to give all the common accomplishments and methods of accomplishing would involve listing all the adjectives which might modify the words behavior, response, reaction, act, and activity and most of those which might modify the word man and also the nouns corresponding to these adjectives.

FIELDS OF ACTION

Still another method of classification is based on the phase of environment to which one is adjusting. Our modern life consists of physical, vocational, civic, educational, recreational, religious, and personal activities. The acts demanded in one vocation differ widely from those in another. The recreation

of one person is highly different from that of another. But each person has some means of earning his livelihood and some way of obtaining recreation. In a like manner each of us engages to a greater or less extent in each of the other phases of life.

We usually characterize a given person on the basis of his achievement in one of these divisions, most often perhaps on the basis of the vocation followed. He is a banker, a baker, a tailor, a mechanic, a lawyer, or a teacher. The fact that individuals A and B are lawyers, however, tells us little about them. One may be civic-minded and the other not; one may be religious and the other not; one may love golf and the other despise it. If, however, we rate or characterize a person in every department of action, we obtain a rather full picture of his individuality.

SUMMARY

It is hoped that this brief chapter will have served: (1) to point out both the value and the fallacies of the doctrine of instincts, the usefulness of the concept of instincts in describing behavior and the illegitimacy of considering common modes of behavior as due to inheritance or as caused by non-physical entities resident within one, (2) to show that the behavior of men may be cross-sectioned in many ways: on the basis of the consequences of the acts, on the basis of the procedure followed in making adjustment, and on the basis of the phase of environment to which adjustment is made, (3) to point out that any form of cross-sectioning reveals features common to all men, and (4) to make clear that common features of behavior are explicable in terms of common features of biological construction.

QUESTIONS AND EXERCISES

1. In general, acts may be grouped on three bases. Those included in a given group may have a common cause, may have common characteristics, or may have common results. Examine Thorndike's list of "instinctive reactions," pick out twelve, and state the basis on which each class-name is derived.

2. Is the instinct doctrine primarily a bio-physical or a bio-social concept? To what extent is the confusion arising in connection with the treatment of

instincts due to a lack of differentiation of bio-physical and bio-social description?

3. Discuss the notion of instinct in relation to desire, habit, intention, and incentive or motivation.

4. When a person acts in a greedy way, what difference does it make for purposes of prediction and control whether that act be attributed to an instinct of greed or be considered a common mode of behavior developing in the majority of people as a result of heredity and environment?

5. If a person is open-minded in respect to certain questions, is he necessarily open-minded in respect to others? Answer the same question for three of the other habits listed by Chapman and Counts.

6. Make a list of habits which are the antitheses of those included in Chapman and Counts' list. Does the development of the habits included in their list involve definite training in the elimination of acts which would be classed in your list?

7. How would you account for the fact that one may enjoy a business associate whom one dislikes socially?

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See also division A of the references of Chapter 7.

CHAPTER 14

MAN'S NON-INSTRUMENTAL ANALYSIS OF THE WORLD

As there is similarity in the accomplishments of men and in their modes of accomplishing, so there is agreement as to the nature of the stimuli affecting them. We experience no difficulty in persuading others that red is red, that middle C is middle C, that the odor of peppermint is the odor of peppermint. Those using a different language may call these stimuli by names other than those which we employ, but we all concur in the opinion that the distinction is one of language, not one which indicates a difference in what is sensed. We detect objects and occurrences, brightnesses and colors, noises and tones, odors, pressures, temperatures, tastes in the world about us, and whatever our language we feel certain that others find the same things.

NON-INSTRUMENTAL IN CONTRAST TO INSTRUMENTAL ANALYSIS

The chemist and physicist in following their sciences do not deal with colors, noises, odors. Rather, they concern themselves with light waves, sound waves, chemical emanations. The activity of a tuning fork the physicist defines in terms of the frequency of air vibrations as detected by an instrument, while man without sensory supplementation defines it in terms of pitch. A given tuning fork may be defined as one producing 256 double vibrations per second or as one whose pitch is C. The stimulations afforded by a surface may be defined in terms of the wave lengths of the reflected ether waves as measured by a physicist or in terms of hue and brightness, *e.g.* a given surface may be defined as one reflecting predominantly waves from 760 to 740 millionths of a millimeter in length (abbreviated

$\mu\mu$) or as red. Salt is found by the chemist to be constituted of sodium chloride molecules, while by man unaided by instruments it is defined by its characteristic taste. Rotten eggs are found by the chemist to give off hydrogen sulphide gas, while we with our olfactory apparatus find them to give off an offensive odor. In short, two ways of defining stimulations are current, the one in terms of their effects upon the instruments of the chemist and physicist and the other by their effects upon man unaided by instruments. Let us call the former an instrumental definition and the latter a psychological one.

The one manner of defining is as easily understood as the other. The statement, "This piece of paper is red," is as clear as the statement, "This piece of paper is absorbing all light rays except those whose length is nearly $760 \mu\mu$, and these it is reflecting." Both imply the objective existence of the paper and its characteristics. One statement may be as severely attacked as the other on the basis of whether this assumption of objective existence is justified. It may be, as some philosophers would hold, that "red" is my response, but if so, it is equally true that "absorption and reflection" and "ether waves" are my responses. As a psychologist I need not concern myself with this problem as to whether objects and occurrences are subjective or objective any more than does the physicist. If he makes progress and is understood when he assumes objective existence, I may hope to proceed with the same assumption.

The physicist and chemist can tell in great detail what they find in the universe, but since their findings are so foreign to our everyday experiences, psychologists have taken up the task of analyzing the world as it appears to men through their unaided sense organs. In fact, this problem has been conceived by a group of psychologists as the paramount task of psychology. This group is commonly known as the structuralistic psychologists, of whom Titchener is generally recognized as the greatest. He said in his book, *A Beginner's Psychology*: "We find that the field of science has been surveyed from two different standpoints. Men of science have set out, on the one hand, to de-

scribe the world as it would be with man left out. The result is what we call physical science. The world of physics is colorless, toneless, neither warm nor cold: . . . But *men of science have tried, on the other hand, to describe the world as it is in man's experience, as it appears with man left in; and the result of this endeavor is psychology.*"¹

From this standpoint the external world becomes several worlds, one for each type of sense organ, *i.e.* there is a visual, an auditory, an olfactory, a gustatory, and a tactual world. In addition, there is the inner world which is detected through our kinaesthetic and organic receptors. The problem is first to analyze these worlds into their simplest components and then to synthesize them into the one world filled with objects and occurrences. The structuralists have done this in an admirable way, and all we shall do here is to present as clearly as possible their major results, re-interpreting them slightly to coincide with the viewpoint of this book.

THE METHOD OF NON-INSTRUMENTAL ANALYSIS

The manner in which a non-instrumental analysis is made, we described in a previous connection. The conclusion may be restated here. A stimulus or a group of stimuli which appears in a number of different situations comes to elicit substitutively a definite response if the unconditioned excitant for that response is present in all situations. If on all occasions in which a dog is fed a musical chord is sounded, the chord becomes capable of eliciting the response originally belonging to food. The chord is analyzed out of or is abstracted from the total situation. If one note is sounded now as a part of one chord, now as a part of another, that note is abstracted from the chord, and the response may be referred to it. After separate responses have been established to single notes, a chord is no longer a chord but a sound composed of several definable notes. Because of the variation in the accompaniment of given stimuli, stimuli come to be separable from their accompaniments.

¹ Page 8.

By the time we become adults we have in this manner become capable of analyzing objects and occurrences with a fair degree of completeness. We have become capable of conceiving leaves as separate from trees because leaves are not always found on trees, wheels as separate from automobiles because wheels are not always found on automobiles, extension of the leg as separate from walking because people are not always walking when they extend their legs. If, then, an adult is confronted by an object and asked to define it as completely as possible, he names as many of its parts as he has learned. The structuralistic psychologist does this, only he carries analysis further than most of us can. He is enabled to do this through variation and recombination of stimulations. For example, if he is confronted by a piece of paper and asked to define its color, he determines whether he can duplicate it by mixing other colors. In this case, he defines it in terms of these other colors. When subsequently he encounters a similar one, he finds in its appearance indications of the components. He can obtain orange by mixing red and yellow; and in looking at it, we can agree with him that it resembles both. In this way the stimulations for each sensory field are analyzed until no further analysis is possible. When a stimulation which is incapable of analysis is encountered, it may be referred to as a psychologically simple stimulus.

A COMPARISON OF PSYCHOLOGICAL SIMPLICITY AND PHYSICAL SIMPLICITY

A psychologically simple stimulus may not be simple when analyzed by the instruments of the physicist, and one found simple by the physicist may not be simple psychologically. When stimulated by what the physicist knows to be a mixture of all light rays, we cannot with our eyes detect any resemblance to red, yellow, green, blue, or any other color, but detect only white. White is psychologically simple but physically complex. When stimulated by what the physicist knows to be ether waves $660\ \mu\mu$ in length (orange), man can detect a similarity to both red and yellow, *i.e.* he reacts as if stimulated by waves $760\ \mu\mu$ in

length and $500\ \mu\mu$ in length. To the physicist the rays of this region are the same as those of any other region in every respect excepting length, but the psychologist finds the stimulation afforded by them to be complex. There is little correlation between complexity of stimuli as detected by instruments and as detected by man.

It does not seem amiss to remark also that there is no correlation between complexity of stimulation and complexity of reaction. The baby reacts to a chair in as simple a fashion as to a straight piece of wood. The dog which has been trained to secrete saliva in response to the ringing of a bell reacts to this substitute stimulus as simply as he would to a tuning fork had it been used in training. Even after we have become capable of analyzing stimulations into their components, we usually respond to them in a unitary way, respond to the stimulation as a whole, a unit, a pattern. Only under certain circumstances do we make analysis and respond to the stimulation as a complex of parts. Usually the visual stimuli afforded by a chair lead to a simple response, but in buying a chair, we take note of the parts. In fact, these analytical reactions are evoked only in response to complicated stimulating conditions. The psychologist does not react merely to the stimulation which he is analyzing but to all those conditions which lead him to attempt the analysis.

THE ACCURACY OF NON-INSTRUMENTAL DIFFERENTIATION

Analysis implies differentiation. To detect orange one must be able to differentiate it from red. To sense peppermint gustatorially one must be able to differentiate it from pineapple. To hear middle C one must be able to distinguish between it and other notes. The question arises as to how accurately man can differentiate or discriminate. As compared with the instruments of the physicist, he is found to be relatively inaccurate. For example, few people in listening to a tuning fork could say exactly what its pitch is, while instruments would measure the rate of vibration with a high degree of accuracy. It is in the

interest of exactness that psychologists usually define their stimulations in the terms of the physicist. Whenever possible in an experiment, the experimenter determines the nature of the stimulation instrumentally, while the subject reports its nature as he discerns it through his unaided sense organs.

Many investigations have been conducted with a view to finding the acuteness of the various sense organs. It is found that on the average one object similar in all respects excepting weight to another must be $\frac{2.5}{1000}$ heavier than the other to be discerned as heavier. If a person is just barely able to distinguish two weights of 100 and 102.5 grams, he is just barely able to distinguish two of 200 and 205 grams or two of 300 and 307.5 grams and is just as able to distinguish two of 10 and 10.25 grams or two of 40 and 41 grams, *i.e.* the just discernible difference is always a difference in instrumentally measured weight of $\frac{2.5}{1000}$, not a difference of a definite number of grams. The fraction of least perceptible intensity difference (abbreviated L. P. D.) is called the Weber Constant, due to the fact that Weber first made extensive investigations with reference to these differences and formulated his results in a law. The Weber Law states that the difference in the intensity of two stimuli is just discernible when the two differ by a certain proportion, not by an absolute amount. Table 2 gives the values of the Weber Constants for the various sense fields and also the range

TABLE 2
VALUES OF THE WEBER CONSTANTS
(From Warren)

SENSE FIELD	L. P. D. INTENSITY	INDIVIDUAL RANGE
Visual (light)	0.01	0.015 to 0.005
Auditory (noise)	0.33 $\frac{1}{3}$	
“ (tones)	0.15	0.20 to 0.125
Olfactory	0.25	0.33 to 0.25
Gustatory	0.25	0.33 to 0.25
Tactile	0.05	0.10 to 0.033
Warmth	0.036	
Cold	0.036	
Kinaesthetic (weights)	0.025	0.05 to 0.013

from person to person. Weights are distinguished kinaesthetically, and it will be noted that the average value is .025, the value we employed in illustrating the Weber Law.

It will be observed that the Weber Law is stated for intensity only, not for color and pitch. There is no simple way of stating the difference in wave length of light rays or the difference in vibration rate of sound waves necessary for non-instrumental differentiation. There are approximately nine hundred distinguishable pure hues corresponding to the instrumentally measured ether waves from 760 $\mu\mu$ to 390 $\mu\mu$ in length and about 11,000 pitches corresponding to the instrumentally measured sound waves from 14 to 30,000 vibrations per second. Finer discriminations can be made in some regions of the spectrum than in others and in some regions of the audible scale than in others.

Not only do instruments detect smaller differences, but they detect smaller absolute intensities. Light which cannot be seen, *e.g.* that coming from some of the distant stars, can be detected instrumentally; sounds too weak to be heard may register on instruments; weights too small to be felt may be weighed on scales. A stimulus too weak to be sensed is said to be below the stimulus threshold or limen. According to Langley, the light which can just barely be seen under the most favorable conditions possesses an energy of 0.000,000,03 erg. The faintest audible sound is produced by dropping a cork weighing one milligram from a height of one mm., the ear being 91 mm. distant. The least observable odor varies widely according to the substance used; for mercaptan it is about 0.000,000,043 milligram in a liter of air. The least amount of quinine that may be tasted is one part in 390,000 parts of water, of salt one part in 2240 parts of water, of sulphuric acid one part in 2080 parts of water, and of sugar one part in 199 parts of water. The smallest weight that can be detected is a cork weight of two milligrams on the tip of the finger.²

² These values are taken from Warren, H. C., *Elements of Human Psychology*.

METHODS OF DETERMINING THE ACUTENESS OF DISCRIMINATION

When the smallest discernible difference has been ascertained, it is said that the person's discrimination threshold has been found. It may be well to describe in some detail the methods for making these determinations. There are two types of methods, one for determining absolute discrimination, and the other for ascertaining relative discriminations. There are many variations in each type, but the former utilizes simple conditioning while in the latter the two stimuli to be discriminated are paired in space or time.

A. The Conditioned Reflex Method.

It will be remembered that as an animal is trained by presenting a substitute stimulus in conjunction with an unconditioned one, other stimuli to be effective must resemble more and more closely the one used in training. If a dog is trained with a tuning fork whose vibration frequency is 637, any other frequency at first elicits a flow of saliva. After a prolonged training only frequencies between 594 and 680 are effective. With continued training these frequencies remain effective. The dog cannot be taught to react differently to a fork whose frequency is 637 and one whose frequency is 679. His discrimination threshold for pitch has been determined. In man verbal responses are conditioned rather than salivary responses. Man is taught to say "C" when middle C on the piano is sounded. With a great deal of training he says "C" only when C or a tone very close to it is presented. By finding just how close to C the one must be in order to elicit the verbal response, "C," we determine the subject's discrimination threshold for tones. Very few of us are trained for absolute pitch, and consequently a note considerably higher or lower than "C" may be called "C."

B. The Method of Paired-Comparisons.

In employing this method with animals, we may require the animal to turn left or right according to the side on which a particular stimulus is presented. If there is paired with this

stimulus one which is highly dissimilar, the animal readily learns to make the correct turn, but as the paired stimuli grow more and more nearly alike, a point is eventually reached at which the animal no longer makes the correct choice. By chance he would make the correct turn on half the trials, while if the discrimination is perfect he would never fail to make the correct response. Consequently if 75 per cent of the turns are correct, it is said that he is just barely able to discriminate.

For the sake of convenience we require in the case of man a verbal rather than a manual response. The subject may say, "Right" or "Left" instead of turning right or left. When the stimuli are paired in time, he may say, "First" or "Second" according to the time of occurrence of the standard stimulus. When time pairings are used for animals, the animal may be required to turn left when the standard stimulus is given first and to turn right when the standard is given second.

We have been speaking of the discrimination of auditory quality. The same methods would be employed to determine the discrimination threshold for intensity, duration, and location of auditory stimuli, as well as the discrimination thresholds in other sense fields.

THE AUDITORY WORLD

A. Psychologically Simple Stimuli.

Any single frequency of air waves is discriminated as a pitch at some approximate point in the range from lowest to highest. Any one of these stimuli is psychologically simple but may be discerned as varying in intensity, duration, and direction. The variation in intensity is discriminated as loudness. The direction from the individual is recognizable if the sound waves strike one ear more strongly than the other, and of course duration is also distinguishable. Thus there is possible an infinite number of discriminations of psychologically simple auditory stimuli. This number is the number of discriminable frequencies (about 11,000) times the number of discernible intensities times the number of detectable directions times the

number of perceptible time intervals. We shall presently consider the discrimination of time and space and in this section will treat only the qualitative and intensity characteristics of stimuli. The simple auditory stimuli can be represented on a surface, the various frequencies arranged along the vertical axis and the intensity along the horizontal axis. (See Figure 28.)

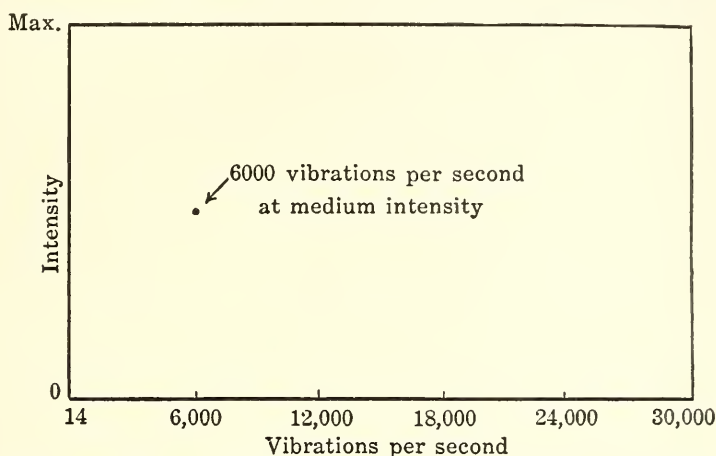


FIG. 28.—Representation of simple auditory stimuli. Any point represents a definite frequency at a definite intensity.

One intensity must be about one-third greater than another by the physicist's measurements if the two are to be noticeably different to man.

B. The Results of Mixing Simple Stimuli.

When two frequencies are active at the same time, we can detect not only their pitches but also beats or difference tones and summation tones. Suppose a tuning fork whose frequency is 256 is sounded simultaneously with one whose frequency is 257. The air impulses will at one time in the course of a second reinforce each other and at another time will tend to neutralize each other. At the moment of reinforcement the intensity is approximately equal to their combined intensities, and when they neutralize each other, the resulting intensity approaches zero. Thus there is a fluctuation of intensity, *i.e.* a rise and fall,

once per second, which we call a beat. All rates of fluctuations up to 16 or 20 per second are heard as beats; but when they become more rapid, we hear them as a pitch, the height of the pitch depending upon the frequency of reinforcement and neutralization. Besides these difference tones we may also detect a pitch which is as high as that produced by a fork whose frequency is the sum of the two simultaneously active forks. This is called the summation tone.

Most auditory stimulations, as they occur about us daily, are much more complex than this. We divide them into two sorts, tones and noises. In tones there is some predominant pitch or a set of predominating harmonious pitches, while in noises these characteristics are lacking. The note given off by a musical instrument is never a single pitch but rather is the combination of a fundamental pitch and several overtones. The first overtone has a frequency twice that of the fundamental, the second one a frequency three times that of the fundamental, etc. The difference in timbre of various musical instruments is a function of the number of overtones present in the tones produced by them. Musical instruments are so constructed that the fundamental frequencies of the various notes stand in simple ratio to each other. Two notes an octave apart have a frequency ratio of 1-2. C and G have a frequency ratio of 2-3, G and C' a ratio of 3-4, C and E a ratio of 4-5. In general, the simpler the frequency ratios the more harmonious the two notes when sounded together. As the ratios grow more complex, numerous beats result, and the chord has little tonality, *i.e.* definite frequencies cease to be outstanding. Furthermore, sounds, as they normally occur about us, vary from instant to instant as in a melody when first one combination is produced and then another. Or the combinations are repeated from moment to moment as in the ringing of a telephone. It is safe to say that the number of discriminable sounds is infinite, and it is to be remembered that on most occasions we react to a combination or a temporal sequence in as simple a fashion as to a pure tone.

THE VISUAL WORLD

A. Psychologically Simple Stimuli.

From the standpoint of the physicist all simple stimuli can be represented on a surface in the same manner as auditory stimuli. But we have already pointed out that there is a discrepancy between what is simple to the physicist and what is simple to a person unaided by instruments. Using physically simple stimuli in medium intensities, man would find but four of them simple: red, yellow, green, and blue. All others would appear as mixtures of two of these. Those frequencies between red and yellow appear as both reddish and yellowish, those between yellow and green seem to be composed of both hues, those between green and blue resemble both these colors, and those whose frequency is greater (wave length shorter) than that of blue appear to be a mixture of blue and red. These four stimuli are, then, psychologically simple.

In addition, white and black must also be regarded as belonging to this class. Physically, white is a mixture of waves of all frequencies, but when stimulated by this mixture, we see nothing of red, yellow, or any other hue. Without the aid of instruments we can analyze it into nothing simpler. Black surfaces are by the definition of the physicist those reflecting no light waves. Black is different from darkness in that it is an area reflecting no light rays surrounded by areas that are reflecting. There has been much debate as to how we can make a visual reaction to areas that are not reflecting ether waves. When it is recognized that man makes localizing responses to certain portions of the total stimulation and considers the part localized as the substitute stimulus for the reaction, the debate is beside the point. Black areas become substitute stimuli, are as readily localized, are just as easily abstracted from the total stimulation as is any other area. No stimulus has discrete existence but only existence in relation to the totality of existing things. We define an area reflecting no light by calling it black just as we define one reflecting predominantly waves from 760 to 740 $\mu\mu$ in length

by calling it red. To be sure the physicist's definition is different, but he is differentiating areas on the basis of their influence upon instruments and not on the basis of their direct effects upon him. We see a black area not as composed of red or any other hue, and neither do we see it as composed of white. It must be considered a psychologically simple stimulus.

B. The Results of Mixing the Simple Stimuli.

Psychologically simple stimuli may be secured for use in studying discrimination in one of three ways. The white light from the sun or artificial white light may be used as a source. If passed through a prism the component rays are separated and all except the ones desired may be screened from view. If one desires to stimulate the subject simultaneously with red and green, these wave bands may be allowed to pass through a screen, and then both may be directed upon a reflecting surface (white in daylight) which is in his view. The same results may be obtained by employing color filters. Two sources are required if it is desired to stimulate him simultaneously with two wave bands. One filter, let us say, allows green waves to pass through and the other red, and the subject views both as they are reflected from a single surface. A simpler way is to employ properly colored papers or other pigmented materials. If these papers are cut so as to make discs and then mounted on a motor so that a part of each disc is exposed, the rays from each sector come during rapid rotation from every point on the whole wheel and those from any one disc are followed so quickly by those from another that practically the same effect is produced as when the rays are simultaneously reflected. To avoid confusion, we shall discuss the results of color mixing as obtained when employing color discs rotated on a motor.

1. *Mixing black and white.* When black and white are mixed in various proportions, grays result. The greater the proportion of black the darker the gray, and the more white used the lighter the gray. The possible results may be represented as points on a line between black and white. This may be termed

the brightness line, the degree of brightness varying from zero (black) to maximum. About seven hundred degrees of brightness can be discriminated using the method of paired-comparisons.

2. *Mixing a hue with black, white, or gray.* Any hue mixed with black becomes darker, and mixed with white it becomes lighter. Its shade is changed. If it is mixed with a gray as bright as itself (neutral gray), it becomes washed-out or desaturated. Its tint is changed. When it is mixed with a gray darker or lighter than itself, both its tint and its shade are altered. The results of these mixtures may be represented on a triangle as in Figure 29.

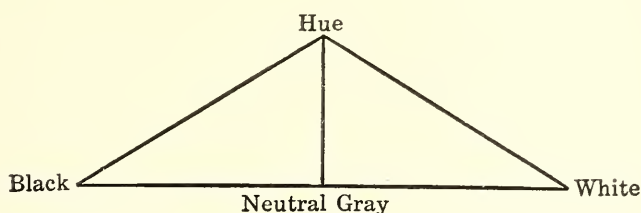


FIG. 29.—The color triangle. The apex represents a given hue at maximum saturation, the base the degrees of brightness, the median the degrees of saturation, the left hypotenuse the dark shades, and the right hypotenuse the light shades. Any point within the triangle represents the hue in a definite shade at a certain degree of desaturation.

3. *Mixing a primary hue with an adjacent one.* By mixing red and yellow, all hues between red and yellow in the spectrum may be obtained. In a like manner the mixing of yellow and green and of green and blue results in the intermediate hues. By mixing blue and red, all hues which correspond to wave lengths shorter than blue are obtained, *i.e.* the indigos, magentas, and violets; and in addition there are produced hues which have no counterpart in the spectrum, the purples. Since in non-instrumental analysis the indigos, magentas, and violets resemble both red and blue and since the purples are bluish red, the hues may be best represented on a circle as in Figure 30. Mixing any two primary hues adjacent on this circle results in an intermediate hue.

4. *Mixing complementary hues.* If two hues which are diametrically opposite on the color circle of Figure 30 are mixed in the proper proportion, all hue disappears and a medium gray is produced. The colors which produce gray, when mixed, are said to be complementary. Blue and yellow are complemen-

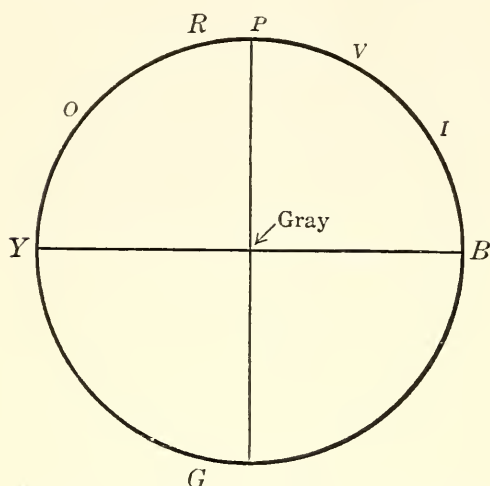


FIG. 30.—The color circle. All hues in their maximum saturation are represented on the circumference, while any point within the circle represents a definite hue in a definite amount of desaturation. Mixing adjacent primary hues results in intermediate ones. Diametrically opposite ones are complementary. Mixing others gives a partially desaturated intermediate hue.

tary, but the red and green which are regarded as psychologically simple are not. Rather the complement of red is a bluish green and the complement of green is a purple or bluish red. Notice that the truth of this is indicated on the color circle. Red and green are not placed diametrically opposite. Not only do the primary colors have complements but every hue has its complement. Diametrically opposite orange is blue-green or peacock, and these two colors when mixed in proper proportions produce gray. There

is a formula by which the exact wave length of a color's complement may be found, but it need not be given here, since the complement is approximately the one diametrically across the color circle.

If two complementary colors are not mixed in the correct proportion, a tint of the predominating one remains. For example, if a color disc is made up of 75 per cent blue and 25 per cent yellow, the disc during rapid rotation appears as a desaturated blue. The yellow neutralizes approximately one-third of the blue so that the disc has the same appear-

ance as would one made up of 50 per cent gray and 50 per cent blue.

If the radii of the color circle were drawn, each radius would represent the tints of the hue to which it extended. The center of the circle would represent gray. If a diagram is made as in Figure 31, the results of mixing all hues with all degrees of brightness are represented. The brightness line is diagrammed as running through the center of the color circle at right angles to its plane. This color cone is made up of an infinite number of color triangles.

5. *Mixing a hue with one neither adjacent nor diametrically opposite.* If yellow is mixed with violet (a combination of red and blue), a desaturated orange results. The blue of the violet neutralizes a part of the yellow, and the remaining yellow blends with the red to produce orange. The result from mixing yellow and violet could be matched by mixing orange and gray. When yellow is mixed with any hue between blue and red, a desaturated orange results, the more red the hue the less the desaturation and the more blue the greater the desaturation. In a like manner yellow rotated with any color between green and blue produces a desaturated yellow-green, blue rotated with any color between red and yellow produces a desaturated magenta or with any color between green and yellow produces a desaturated peacock. Mixing red with any color between yellow and bluish green does not give analogous results, due to the fact that red and green produce a desaturated yellow, the

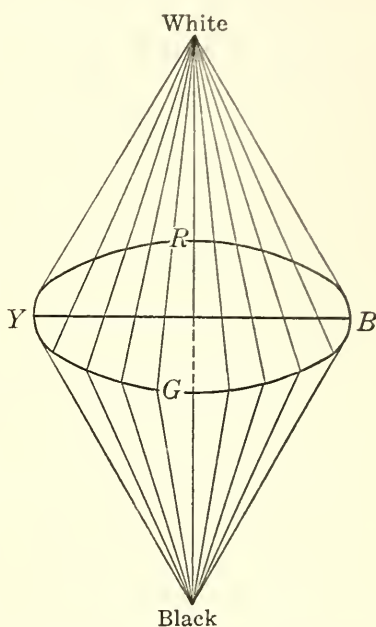


FIG. 31.—The color cone, a combination of the color circle with the color triangle of all hues. It represents all hues in all shades and saturations.

amount of desaturation being approximately that produced by rotating one part of yellow with four parts of gray. It will perhaps be best to state three rules which cover all cases of mixing hues. (1) Adjacent hues give intermediate ones. (2) Yellow and blue give gray. (3) Red and green give 80 per cent desaturated yellow. From these three rules one can calculate the approximate result of mixing any two hues. For example, if a disc is made up of 50 per cent orange and 50 per cent blue, the effects of rotating it are the same as if a disc were made up of 25 per cent yellow, 25 per cent red, and 50 per cent blue. The yellow neutralizes one-half the blue, giving an amount of gray equal to 50 per cent of the disc. The remaining half of the blue and the red blend to produce violet in an amount equal to 50 per cent of the total disc. The result is a 50 per cent desaturated violet. Or again, if a disc is made up of 50 per cent green and 50 per cent violet, the effects of rotating are the same as if a disc were made up of 50 per cent green, 25 per cent red, and 25 per cent blue. The red combines with half the green to produce the equivalent of 10 per cent yellow and 40 per cent gray. This yellow neutralizes an equal amount of the blue to produce 20 per cent gray. The final result then is a 60 per cent gray, 15 per cent blue, and 25 per cent green, a desaturated bluish green. In like manner the effects of combining any two hues may be calculated.

C. The Number of Visual Stimuli.

When only the hue and brightness are varied, the number of possible discriminations is large, estimated at 50,000. The visual stimuli arising from surfaces are in most cases not uniform over the whole surface; millions of patterns are possible on a surface which is twelve inches square. In addition, the surfaces may differ in their contour and furthermore may be in any one of many directions. Besides these variations the stimuli may change location, and there may be shifts from time to time in the pattern. Through vision more than any other sense field we are enabled to differentiate the objects and occurrences in our environment.

THE OLFACTORY WORLD

A. Psychologically Simple Odors.

Through smell we detect odors, of which six are highly dissimilar and also unanalyzable. These six are most commonly given as follows:

Spicy, found in pepper, cloves, nutmeg, etc.

Flowery, found in heliotrope, etc.

Fruity, found in apple, orange, oil, vinegar, etc.

Resinous, found in turpentine, pine needles, etc.

Foul, found in hydrogen sulphide, etc.

Scorched, found in tarry substances.³

As far as can be determined, the substances which give rise to any of these odors possess no common chemical characteristic.

B. Mixture of the Simple Odors.

Other odors which are innumerable are to be regarded as mixtures of these six. A combination of resinous and scorched produces the odor of roasted coffee, that of fruity and spicy the odor of peppermint, etc.

THE GUSTATORY WORLD

Chemicals dissolved in the saliva are detected through taste as either salt, sour (acid), bitter, or sweet or as possessing some combination of these four elementary tastes. When popularly we speak of the taste of a food, we mean its characteristics as detected through taste, smell, and stimulation to the lining of the mouth.

THE CUTANEOUS WORLD

The end-organs embedded in the skin enable us to detect temperature changes, pressures, and noxious stimuli. Moderately low temperatures are discriminated as cool, while very low ones are detected as both cool and painful. Moderately high ones are sensed as warm and still higher ones as warm and painful. Objects in contact with the skin exert pressure

³ Woodworth, *Psychology, A Study of Mental Life*, page 203.

which is sensed as strong or light pressure. If the pressure exerted is intense, it is sensed also as painful. Through simultaneous pressure at many points on the skin or through pressures at varying intensities over a short period of time, objects are discriminated as being hard or soft, smooth or rough, etc.

Weights are discerned not so much by virtue of the pressure afforded as by the amount of muscular strain involved in lifting them, *i.e.* through the resulting kinaesthetic stimulations.

SYNAESTHESIA

Hardness and softness are discerned primarily through the readiness with which objects yield to the pressures we place upon them. After an object's firmness has been discovered in this manner, it *looks hard*. The discernment through one type of sense organ of a characteristic of an object detected primarily in another sensory field is known as synaesthesia. In most cases synaesthesia is explicable in terms of simple conditioning. At the time we discover the hardness of an object, we are also visually stimulated by it. Its visual stimuli for this reason come to evoke a perception of its hardness.

The visual world is more than the visual world; it is all worlds combined in one. A chair is not seen merely as a pattern of brightnesses and colors but as a chair, hard, smooth, heavy, strong, comfortable. Water is seen not as a pattern of brightness, tinted bluish green, but as water, fluid, wet, drinkable. In a like manner each world is supplemented by all others. A buzz is not merely a pattern of pitches of a certain intensity but the buzz of a fly, a bee, an aëroplane.

It is because we find in one form of stimulation the properties discovered through other sense organs that we often interpret erroneously. If we stopped with the conclusion that a buzz is a buzz instead of going a step further to call it the sound of a fly, we could not mistake the buzz of a fly for the whirr of an aëroplane. If we never decided before picking up an object that it is heavy, we should never misjudge its weight.

Unless, however, we did interpret stimuli, this would be a queer disjointed world. The advantages accruing from interpretation greatly offset the misinterpretations which we occasionally make. Our conditioned responses, our synaesthesias, our "responding as if," make objects things to which adjustment may be made. It would be highly inconvenient if a chair could not be visually discerned as strong, or a lighted gas jet as hot.

Occasionally a person is found who possesses unusual and non-adjustive synaesthesias. One of the most common of these is the tendency to hear pitches in terms of colors. Low notes are blue, middle ones red, and high ones yellow. Other strange synaesthesias are reported by Galton in *Inquiries into Human Faculty and Its Development*. Just what sort of conditioning is responsible for these peculiar reactions is unknown.

THE WORLD OF SPACE

Up to this point we have dealt with the world of stimulus-qualities and stimulus-intensities. We assume that the objects which give rise to stimulations exist in time and space. To see an object as near or far or to discern it as a solid having three dimensions is analogous to synaesthesias. In moving about, we receive stimulation from an object at varying distances. Through our kinaesthetic receptors we discern the amount of movement involved in reaching an object, and soon the peculiarities of its visual stimulation at a distance enable us to judge its distance. In other words, the perception of distance is essentially a conditioned response. The infant in its random behavior reaches to objects at varying distances, and the child walks or rides to objects or throws stones at them at different degrees of remoteness. The characteristics in the visual stimulus-pattern which vary with different space intervals come to act as substitute stimuli for reaching or walking a given distance or for throwing a stone with the required force, or in adults for eliciting a verbal response designating the distance. These stimulus-differences may be listed as follows:

- (1) The size of the resulting retinal image—the nearer the object the larger the image.
- (2) The position of the object vertically in the field of vision, near objects being below more distant ones.
- (3) The partial obscuring of one object by a nearer one.
- (4) The amount of detail, near objects appearing with clear outline and in true colors.
- (5) The relative motion of an object when the person moves, near objects seeming to move in the opposite direction from that in which the individual moves and far ones seeming to stand still.

In addition to these characteristics are two sets of stimulating conditions arising in the eye muscles. The ciliary muscles which

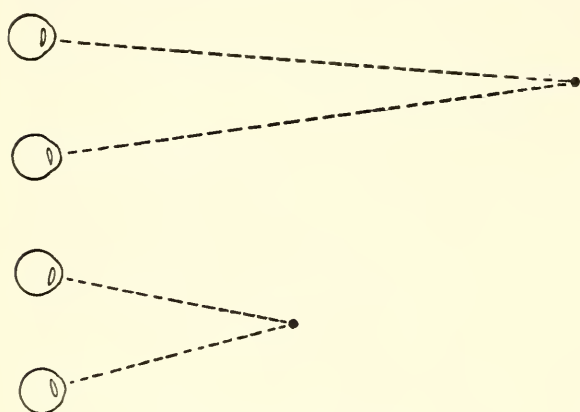


FIG. 32.—Illustrating difference in amount of convergence of the eyes with varying distance of objects.

control the curvature of the lens reflexly contract or relax until a clear image of the object is produced on the retina. For near objects they must contract to a marked extent to achieve a clear image, while for far ones they must relax. When focus is achieved, there is a particular

amount of strain in these muscles, and the amount of strain acts as a clue to the distance of the object. The eyes also tropistically turn to the object. When the object is near, there is a resulting convergence, the nearer the object the greater the convergence. (See Figure 32.) This means a particular amount of strain in the internal recti, and the resulting kinaesthetic stimulation serves as a further cue as to the distance of the object.

Another important cue is the difference in the object's ap-

pearance to the two eyes. With the right eye we see more of the right side of an object, and with the left more of the left side. Furthermore, the near end of an object seems to be displaced toward the left when viewed with the right eye and displaced toward the right when viewed with the left eye. To illustrate this, the reader might perform the following simple experiment. Stand about two feet from a wall. Place one end of a foot ruler against the wall at a level with the eyes and point the ruler toward the bridge of the nose. Close the left eye and notice where the near end of the ruler seems on the wall. Then close the right eye and notice where the near end seems to be. (If, with the left eye closed, the near end of the ruler does not seem to be at the left of the far end, it is because the ruler is being pointed toward the right eye instead of toward the bridge of the nose. In this case, the near end appears far to the right when viewed with the left eye.) Now step as far back from the wall as possible holding the ruler as before. View it first with one eye and then the other. The displacement will not be so great when you are farther from the ruler. In general the difference in the images formed on the two eyes decreases as the object is farther away. The amount of disparity is, then, a valuable index of the distance of an object.

The stereoscope is based on this factor of disparity. An object is photographed by two cameras placed side by side. The two pictures obtained are different to the same extent that the two retinal images would be different if the object were being viewed with the eyes. When placed on a slide and viewed through a stereoscope, the picture taken by the camera on the right is viewed with the right eye and the one taken by the camera on the left is viewed with the left eye. The same perception of depth is possible as would be present were the object viewed directly by the individual. As an illustration of stereoscopic vision Figure 33 is included. The diagram on the left is of a pyramid as it would appear to the left eye and the one on the right is the same pyramid as it would appear to the right eye. Notice that the apex is displaced to the left with reference to

the base for the right eye and to the right for the left eye. To make the diagrams appear as a pyramid in three dimensions, place one edge of a sheet of paper on the dividing line and the other against the tip of the nose and then stare at the diagrams. The eye muscles must be relaxed so that the two diagrams seem to move together until they coincide. When they coincide, the dot representing the apex seems to be out in front of the square representing the base. (A few readers may be

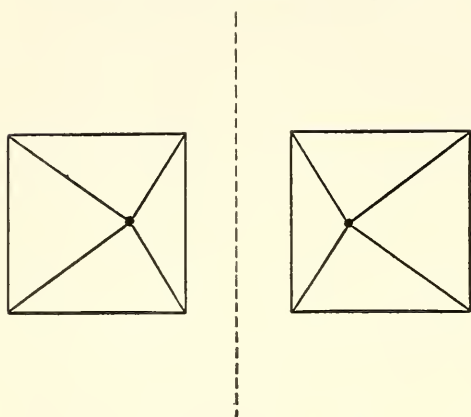


FIG. 33.—Illustrating displacement of near parts of an object with reference to far parts. To be used as directed in the text to illustrate stereoscopic vision.

unable to make the two diagrams coincide at first, but if the eye muscles are relaxed and if one looks at the diagrams with a semi-blank stare, the desired results will be obtained.)

The three cues last discussed serve only for distances up to approximately 100 feet. The ciliary muscles are completely relaxed for all distances over 100 feet, the two eyes are practically parallel, and the image cast upon the one is the same as that cast upon the other. The five factors first listed enable us to discern degrees of remoteness beyond 100 feet.

It may be reiterated that all these characteristics become cues or substitute stimuli only after they have repeatedly preceded a definite act. We have never gone to the moon and so cannot discriminate its distance. It looks small rather than distant. We seldom approach objects from above, and so when we view them from a height, they appear flat and small.

THE WORLD OF TIME

The dog can be conditioned to react to a stimulus on the basis of its duration as readily as on the basis of its quality or

intensity. In this conditioning the duration of the stimulation accompanying the unconditioned excitant must be constant and the quality and intensity varied. Bells whose tones differ in quality, sounded softly on some presentations and loudly on others, are rung for a half second. After sufficient conditioning any one will produce the flow of saliva if sounded for a half second, but not otherwise. The dog learns to abstract duration from all other characteristics. He can also be taught to react to the interval between two stimulations, secreting saliva when the interval used in training is presented and not secreting when other intervals are introduced. Much of our time discrimination is to be explained on the basis of these simple conditioned reflex principles.

Some of our time discrimination is, however, based upon a somewhat different set of principles. It has been repeatedly mentioned that we do not react to isolated stimuli but rather to them in relation to the total situation. The situations change from hour to hour, from day to day, and from season to season. Whatever elements are peculiar to the time of day or year, come to substitutively set off reactions appropriate to that time. The child, if regularly given his breakfast at 7:30 A.M. comes to expect breakfast at that time as the dog comes to expect food when a bell is rung. This is in part due to his having formed the serial habit of eating shortly after rising, but also due to the amount of light, the position of the sun, and the activities in which his parents are engaged. One child at the age of two, calls out, "Start toast" when his father finishes shaving, but does so only in case the father shaves before breakfast. Often a child will misjudge time, for neither his activities nor those of persons about him are completely routinized nor are there discriminable differences in the brightness and position of the sun. As he becomes older, he learns to react to time as indicated on clocks. When still older, he learns to relate acts to the day of the week or month and to the year.

After this conditioning has taken place, an act is not merely an act but also one performed at a given time and under definite

circumstances. When a stimulus occurs to reinstate this act or its verbal substitute, there are released also the verbalizations which designated the time and circumstances of its original occurrence. Three reactions occurring at different stages in a child's life will serve to illustrate this development. A child at the age of one year while walking with his mother saw a latticed porch and said, "Kitty." The mother was puzzled and related the incident to her husband, learning that the previous day a cat had been seen to run under a latticed porch in another part of town. At about the age of two in passing a turkey-pen, the child said, "Mr. M. and Daddy put turkey in pen," as they had done about a week previously. When two and a half he said in response to seeing a new pair of shoes which he had worn but once and to a party, "I went to a party yesterday."

The changes are scarcely to be attributed to the development of language alone but rather reveal a growth in the reaction to attending circumstances. In the first instance only the cat was noted and the surrounding circumstances served to recall only it. In the second the relation was noted not only between the pen and the turkeys but also between the pen and a specific act, and in the third not only between the shoes and the party but also between the party and the time of its occurrence.

In consequence of noting the attending circumstances, we are enabled to discriminate intervals indirectly. We meet an old friend, and the events which we experienced in common as well as the time of their occurrence are reinstated substitutively. We relive the past and in doing so renote the time in which we are imaginatively living. Then, as we come back to the present, we exclaim that it has been ten years since our previous meeting. We do not directly discriminate the interval, but rather an old happening is reinstated in conjunction with present ones and the temporal discrepancy noted, just as the mathematical difference between 1928 and 1918 is observed. When the date of a previous occurrence cannot be fixed, we speak of it as having taken place a long or short time ago. Length applies more

directly to distances, but at an early age we relate the distance to the time required to cover it and soon come to judge intervals subjectively by the intervening amount of action.

When the importance of attending to the accompanying circumstance for recalling incidents is recognized, we can understand how a person in a so-called unconscious state can be active and not be able later to recall what he did. When he is rendered unconscious, the normal action of his nervous system is disrupted so that only unconditioned and highly conditioned stimuli bring about a response, *i.e.* only the reflexes and the firmly established conditioned reflexes remain. These firmly ingrained responses are made irrespective of time, place, and persons present, *i.e.* reaction is made to isolated stimuli, and consequently there is little or no possibility of the reaction being reinstated by the subsequent occurrence of some of the accompanying stimuli.

This leads us to reiterate that, in saying that man is a conscious organism, we mean that he reacts to or verbalizes his behavior in relation to antecedents, accompaniments, and consequences. When we speak of being conscious or unconscious, we refer to a manner of behaving and not to causes of behavior. The causes exist in the nature of man's reactive equipment and in the stimuli to which this equipment is subjected.

SUMMARY

The world has been analyzed instrumentally and non-instrumentally. The elements found in the former analysis are electrons and protons and in the latter are psychologically simple stimuli. Each of the latter type of stimulus has a distinctive quality, an intensity, a duration, and a location. In our daily living we discern not simple stimuli but rather objects and occurrences, for through simple conditioning a stimulus in one sense field comes to evoke responses originally elicited by stimuli in other sense fields.

QUESTIONS AND EXERCISES

1. Write a paper on the methods, results, and significance of non-instrumental analysis as contrasted with instrumental analysis.
2. Discuss the statement, "No stimulus has discrete existence but only existence in relation to the totality of existing things."
3. Calculate the result of rotating on a color wheel a disc made up of 50 per cent yellow and 50 per cent violet. Of 50 per cent red and 50 per cent blue-green. Of 50 per cent red and 50 per cent yellow-green.
4. List as many examples of synaesthesia as you can. Can you explain all in terms of simultaneous stimulation?
5. What would be the result if in preparing a stereoscopic slide, the two cameras were placed two feet apart? How could a stereoscopic slide of the moon be prepared?
6. Surveyors sometimes determine the distance of an object by establishing a base line at approximately right angles to a line between them and the object, measuring off a certain distance, say one hundred yards, on this line, and then with a direction finder measuring the angles formed at the ends of this base line when the instrument is pointed directly toward the object. Compare this measurement of distance with our detection of distance through the amount of convergence.
7. To what extent is appreciation of music related to the ability to analyze musical compositions? To what extent is the appreciation of poetry related to the understanding of metrics? To what extent is appreciation of a woodland scene in autumn related to botanical information? Make a generalization based upon your answer to these questions.

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CHAPTER 15

THE NATURE OF DISCRIMINATIONS

In the preceding chapter we employed the words distinguish, differentiate, discriminate, sense, perceive. If each stimulation set off an immediate overt act, we would find no difficulty in conceiving the results of stimulation as definite physiological effects determined by organismic structure, but in many cases stimulations produce no outward sign or reaction. A person may be requested to look at a red card. All that we can note is that he glances in its direction. As to whether he saw it as red or green or gray, we cannot say. If some time later we ask him its color, he names the correct one. The stimulation must have had some specific and immediate effect which was covert. Our problem is to discover more fully the nature of this implicit effect.

THE RÔLE OF CONDITIONING IN DIFFERENTIATING STIMULI

We have committed ourselves to the view that the ability to make a definite response, whether overt or covert, to each of the many stimulations which we encounter is derived from conditioning. In Chapter 9 we stated that "To *see* (not merely to be stimulated by) an object is to respond either overtly or covertly in a specific way to the visual stimuli arising from that object, *i.e.* to respond in a way different from the manner of responding to other objects." Again, "Visual discriminations are conditioned responses built up through the occurrence of definite patterns of visual stimuli along with certain reactions such as withdrawal and random manipulations." In Chapter 14 we emphasized the importance of conditioning under the heading, Synaesthesia, and in the discussion of space and time perception. If one is born blind and through an operation becomes capable of being affected by light rays, nothing is at first distinguished, if the testimony of the few who have had this experience is

valid. There would be no objects visually discerned, no distance revealed. Only after particular patterns of visual stimulation had been followed closely by definite acts, would objects be seen. Accordingly, it would appear that visual stimuli become substitutively capable of setting off appropriate acts through the process of conditioning.

THE NATURE OF IMPLICIT RESPONSES

We have also discussed briefly the nature of implicit responses. Our conception of their character may be summarized as follows: (1) Stimulation produces a heightened tension in the muscles, skeletal and verbal, involved in overtly responding to the stimulation. (2) Stimulation results in changes in the rate of metabolism in the nervous system, *i.e.* results in the alteration of the gradient patterns. The alteration favors the execution of a definite overt act. (3) Stimulation releases visceral activities which are capable of modifying skeletal and verbal action. The first effect was discussed in Chapter 9, the second in Chapters 4 and 5, and the third in Chapter 10.

An excitant comes to elicit a response whose components are manual, verbal, and visceral. As adults we react to a chair by sitting on it, by talking about it, and by feeling pleased or displeased with it according to the comfort it affords; and we respond in these ways because of our past experience with it. In sensing its presence, we make none of these reactions in an overt manner, but our thesis is that the visual presence of a chair releases these responses incipiently and makes us more ready to respond overtly in these ways.

REASONS THAT STIMULATIONS RELEASE COVERT RATHER THAN OVERT RESPONSES

A. Incompatibility of the Responses to the Various Elements of a Situation.

Stimuli do not occur in isolation but rather as elements in a situation. The response which we have learned to make to one element may be incompatible with the response which we have

learned to make to another. A monkey when offered a banana usually approaches and eats it. If beaten with a stick or merely shown a stick, he runs away. If he is offered a banana on the end of a stick, he neither advances nor retreats. The one stimulus inhibits the response to the other. If the stick is flourished, overt action of one sort appears, and if the person holding the stick speaks kindly, overt action of the other sort follows. Overt action is released not by one excitant but rather by the totality of present stimulation. If the situation contains elements which tend to release incompatible responses, no overt action takes place until one of the elements is removed or until a new factor enters which reinforces one of the components already present. We have learned not only to sit on chairs but also to abstain from seating ourselves under some circumstances. In a like manner many stimulations release no immediate overt action due to the presence of inhibiting elements in the situation.

B. The Development of Responses Substitutable for Overt Acts.

In addition to the absence of reinforcing stimuli or the presence of inhibiting stimuli as factors in explaining the lack of overtness is the fact that we have substitutes, particularly in our verbal equipment, for overt reactions. When an excitant releases a verbal response, we need not make an immediate overt manual response in order to adjust to the stimulation. We may delay skeletal action, while animals lacking substitutive responses fail in their adjustment if they do not make an immediate skeletal response. This is illustrated in Hunter's study of delayed reactions.¹ A dog may readily be trained to secure food in the correct box when a light is flashed over one of several boxes. If a screen or glass is placed in front of the dog, he at first attempts to go through or around the barrier when the light is flashed. Soon, however, he learns to wait until

¹ Hunter, W. S., "The Delayed Reaction" *Animal Behavior Monog.* No. 6. 1913.

the barrier is removed. If it is removed within a few minutes, he goes to the correct box. When the light is flashed, he takes up a definite posture orienting toward the box over which the light has been placed. If this posture is disturbed, the dog fails to go to the correct box. He makes an immediate orientation reaction which must be maintained, and its maintenance precludes the making of any other response. In contrast to these requirements for the dog's success are those imposed upon man. If I brought to class three boxes exactly alike in appearance and told the class that there was a thousand dollars in the box I designated and that any member might have it if a year later he could tell me in which box it was contained, no one would have any difficulty in designating the correct box and no one would have to abstain from his other activities in the interim. Each member would immediately verbally designate the box containing the money. He would say to himself that the money was in the box on the left or right or center as the case might be. For adjustment no immediate overt action is necessary. To say "The money is in the box on the left," is a substitute for going to the box on the left. This verbal response might be made repeatedly, so that the sight of the three boxes a year later would be certain to reinstate it. When reinstated, it would serve to direct overt action. If a dog were allowed to go to the box on the left as often as a person might say, "The money is in the box on the left," the dog, too, could go to the correct box a year later. He would remember what act to perform in the same way we would, by repeatedly performing it. We, however, repeat the act substitutively while the dog must repeat it overtly.

When man makes no immediate overt response, it is in part due to the fact that he makes an implicit substitutive response. When the substitutive reaction has been made, the adjustment to the stimulation is for the time being completed, and man can turn to other activities. He has learned from experience and observation that he may engage upon other activities before making an overt response to a given stimulus. He has found

that after studying the time tables, he may start to the train at the end of several hours and still catch the train. He has found that he may answer questions about what he has seen without making any immediate overt action. He knows that, if he decides, while viewing a crowd bathing at the beach, to go bathing the next day, he need not start immediately to secure his bathing suit.

It is, however, evident that a person, although he makes no explicit reaction to the objects and occurrences about him, is really being affected by these excitants. The visual presence of a chair may not lead him to sit down, but it makes him more ready to seat himself, just as the banana on the stick makes the monkey more ready to approach when coaxed. The presence of objects also leads to making immediate incipient verbal responses. If I hold a coin before you, you find yourself pronouncing its name and perhaps thinking of its purchasing power. If I diagram a radio circuit in your presence, you subvocally wire the set, saying to yourself that the terminals of the primary coil are connected with the aërial and ground, those of the secondary to the grid and minus-filament, etc. A great number of our discriminations are implicit verbal reactions which are thoroughly adapted to multitudinous differentiations.

The rôle played by subvocal responses in discriminations will be readily granted, but in some cases it seems that we do not make even these responses. Some persons testify that when they see red, they do not subvocally say red. Our next problem will concern those implicit responses in which no abbreviated verbalizations are detectable.

EVIDENCE THAT STIMULI PRODUCE DEFINITE PATTERNS OF SKELETAL TENSION

We have suggested under the heading, *The Nature of Implicit Responses*, that a stimulation may give rise to a definite pattern of tension in the skeletal muscles even though it does not release an overt action or a verbal response. We may now bring together evidence for this view.

A. Evidence from Animal Tropisms.

The mythical beast illustration of Chapter 2 may be recalled. It was somewhat inaccurate to say that the light caused the beast to go in its direction. Rather, when the light is to the left, a heightened tension on the right of the animal is produced. Then when locomotion is initiated, action on the right is more vigorous. If the beast remains still, a posture of readiness to turn toward the light is noted. Loeb and his co-workers have found that in many animals a light placed to the left results in a heightened tension of the muscles on the right, one placed to the right produces increased tension in the muscles on the left, one placed above causes a heightened tonus in the ventral musculature, and one placed below gives greater tenseness in the dorsal musculature. They find that the same asymmetry of muscular tension may be produced by blackening one eye or parts of both eyes. The robber fly with the right eye blackened stands twisted to the left as shown in Figure 34. These studies lead to the conclusion that stimulation to given portions of the retina produces tension in definite muscles. A specific pattern of visual stimulation leads to a special pattern of muscle tension.

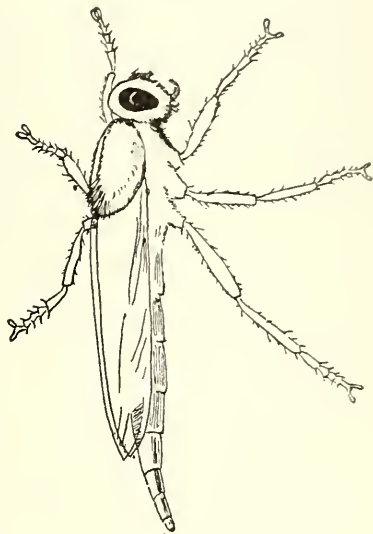


FIG. 34.—Robber fly with right eye blackened, seen from above. Position is such that motion toward the left is possible, toward the right impossible. (After Garrey from Loeb.)

B. Evidence from the Fixation of Lights by Infants.

In infants light striking away from the fovea gives asymmetrical tension in the external eye muscles. As a result the eyes are turned toward the light. When they have been turned

toward the light, the rays strike the fovea and the eyes are held toward the stimulations just as the mythical beast is kept facing the light. In other words, the fixation of lights by babies is essentially a tropistic or orientation reaction on the same plane as the responses of the animals of which the mythical beast is a prototype.

C. Evidence from the Fixation of Objects by Adults.

As adults our eyes do not tropistically turn to the brightest spot in our field of vision. We often fixate black spots which have zero brightness. This is due to conditioning. A dog does not ordinarily orient to the brightest spot in his field of vision; he would not be classed as positively heliotropic. He can, as we have already noted, be trained to orient to a light by the repeated flashing of a light in front of a box in which he may obtain food. If after this training a screen is placed in front of him, he assumes a position facing the box, his eyes fixated upon it. In other words he has acquired a positive heliotropism. He could just as easily have been taught to fixate and go to a box designated by black paper. The important factor in the development of orientation is not the intensity of the stimulus but rather the existence of conditions such that a definite stimulus has preceded a particular response. In animals which are capable of being conditioned, stimuli are not effective in proportion to their intensity but rather in proportion to the amount of conditioning in which they have played a part. Otherwise we could never react to black. Objects in our environment catch our eye on the basis of our past experience with them and on the basis of the setting in which they occur. A lover of books passes a spectacular display of electric lighting apparatus to have his eye caught by a small copy of Keats in an obscure corner of another window. Again it may be said that a definite pattern of stimulation gives a definite pattern of tension in the muscles, in this case the eye muscles.

D. Evidence from Visual After-Discriminations.

If a person is given a strong and continued stimulation by a light in a dark room, he reports that he seems to see the light

after it has been turned off. This is called an after-image or after-discrimination. If the light rays strike the retina away from the fovea, the eyes turn when the light disappears. If during stimulation the subject of an experiment ² is requested to fixate a point slightly to the right of a brightly illumined square, he reports that the after-image seems to move to the left, and the experimenter may observe that the eyes are turning to the left. If the fixation point is to the left of the square, the eye movement is to the right; if above, the eye movement is downward; if below, the eye movement is upward. For each pattern of stimulation there is a resulting pattern of tension in the eye muscles. If the subject were to fixate the center of the square so that the stimulation would be symmetrically distributed about the fovea, it is to be assumed that the tensions would be produced but that equal tensions in antagonistic muscles would be present so that no movement would occur.

THE RELATION BETWEEN EYE MOVEMENTS AND VISUAL AFTER-IMAGES

In the experiment just described, there is the observable turning of the eyes and also the report of the subject that he has an after-image. The question arises as to the relation between the eye movements and the after-image. Further investigation revealed that, in case stimulation was of such a type as to produce movement, the movement must be present if the subject reported an after-image. If stimulation gave a movement to the right, any movement to the left would lead to a report that the image disappeared. For example, if the subject were instructed to follow a knot moving slowly to the left, he would report the absence of the after-image, while if the knot were moving to the right, he would report the image present. This points to the conclusion that the set of muscle tensions imposed by the stimulation is necessary to the report of the after-discrimination.

From this conclusion it may be deduced that the kinaesthetic

² Rexroad, C. N., "Eye Movements and Visual After-Images." *Amer. Jour. of Psychol.*, 40, 426-433.

stimuli arising from the muscle tensions are the substitute stimuli for the verbal report. When describing the after-image, the subject does not, however, describe kinaesthetic stimuli, but rather visual stimuli. This is explained as follows. The visual stimulus, a brightly illumined square, gives rise to a definite pattern of muscular tensions. The subject has in his past learned also to describe the stimulus verbally. When the kinaesthetic stimuli derived from the tensions are present, they act as substitute stimuli, evoking the verbal reaction belonging originally to the visual stimulus. In other words, the verbal reactions in reporting the after-effects of visual stimulation are responses to visual stimuli rather than to kinaesthetic stimuli in the same sense that the secretion of saliva is a response to food rather than to a bell.

If the stimulus for the verbal report in this experiment is the pattern of muscular tensions and if one holds that the verbal report describes an after-image, then *the after-image is the pattern of muscular tensions*.

THE NATURE OF SENSATIONS, PERCEPTIONS, AND IMAGES

These patterns of muscular tension, these non-verbal and non-overt responses, have been considered by the structuralistic psychologists not as the image but as the physical correlate or counterpart of the image. Structuralistic psychologists believe, as does the author, that each stimulation leads to a physiological response and that in many cases the response is implicit. They hold, however, that parallel with, but not caused by, the physiological response there is also a mental or conscious process. Images, sensations, and perceptions are from their view mental processes. Their primary interest is the study of mental processes which they believe are discovered through introspections; but they have an indirect interest in the physical parallels. In consequence they have devoted considerable study to the correlates of images.³ They would, however, not agree to the

³ Washburn in her book, *Movement and Mental Imagery*, presents practically the same conception of implicit physiological responses as has been developed in this chapter.

statement that the image is the physiological response. We may first define sensations, images, and perceptions in physiological terms and then note the reasons for rejecting the concept of mental processes.

Structuralists have defined a sensation as an elementary mental process. Each sensation has three attributes—quality, intensity, and duration; and many have a fourth—extensity. There are six visual sensations—red, yellow, green, blue, black, and white; there are as many auditory sensations as there are pitches; there are four sensations of taste—sweet, sour, salt, and bitter; there are six olfactory sensations corresponding to the six classes of odors given in the preceding chapter; there are four cutaneous sensations—warmth, coolness, pressure, and pain; and there are kinaesthetic, static, and organic sensations. In physiological terms a sensation may be defined as the implicit response made to a psychologically simple stimulus. For example, the sensation of red is the physiological activity released by ether waves $760\ \mu\mu$ in length.

Structuralists have defined a perception as a group of sensations, whether the component sensations are directly released by their stimuli or whether they are released by association. We have perceptions of chairs, trees, automobiles, spaces, time intervals, movements, tones, noises. In physiological terms a perception is the implicit response elicited by a configuration of psychologically simple stimuli (by a stimulus which is not psychologically simple).

They have defined an image as a sensation or a perception when present in the absence of its stimulus. For example, the sensation of red becomes an image of red when there are no ether waves $760\ \mu\mu$ in length present, and the perception of a chair becomes an image of a chair when a chair is not present. In physiological terms a memory image is a definite implicit response released by a substitute stimulus, and an after-image is the definite implicit physiological response which continues after the stimulus has been withdrawn.

REASONS FOR NOT REGARDING DISCRIMINATIONS AS MENTAL PROCESSES

A. The Error of Postulating Mental Processes.

If we had never heard of an automatic telephone switchboard and had occasion to use an automatic phone, we might well be inclined to postulate a consciousness directing the course of connection. The error in assuming consciousness is a refined form of the one leading to animism. That which is hidden from sight and understanding is assumed to be different in nature from that which is seen and known. To say that a man is conscious of an object is merely to say that he is reacting to that object. The physicist may equally well say that an electron is conscious of the protons in its surroundings. In fact, he might with some justification use the words we employ in describing human behavior. He might say that the electron senses the presence of protons, perceives their direction, and judges the difference between them and electrons; or he might say that the electron instinctively avoids the proton and that it wills to survive. In all cases he would be merely describing how the electron behaves. When a psychologist says that a person senses, or perceives, he is only saying how the person acts. It is ineffectual to say that discriminatory responses are conscious or mental processes, for in doing so we learn nothing about them.

B. The Error of Assuming that Introspections Describe Something Within.

The electron cannot tell us in words that it is reacting to protons, while one man can tell another to what objects he is responding. He can make verbal responses to his surroundings and to his own responses. A person who is supposedly introspecting gives a minute verbal description of the stimulus affecting him, of other stimuli with which the active stimulus has been associated, and of the kinaesthetic and organic stimulations derived from the response to it. For example, an introspection made when a chair is visually present would involve

the following parts: (1) a description of the visible characteristics of the chair—its color, shade, brightness, size, shape: (2) a designation of properties previously detected through other sense organs—weight, hardness, smoothness of wood, velvety feel of upholstery: (3) a list and possibly a description of associated objects—tables, people, benches: (4) an inventory and possibly a description of related occurrences—sitting, working, reading: and (5) a specification of internal conditions resulting from the sight of the chair—feeling of comfort, relaxation of definite muscles, tension in others. In all parts of the introspection except in Part 5 (a specification of internal conditions), external stimuli are being described and in Part 5 it is internal physical stimuli which are being designated.

The same set of verbal reactions may be released when the word chair is heard or read. In this case the structuralist would say that an image of a chair was being introspected. Again it is clear that external things are being described in their absence, that the person is making conditioned verbal responses.

The technical terminology of the introspector should not prove misleading. There is no difference between the verbal responses, "I am responding to red," "I see red," "I am conscious of red," and, "I have a sensation of red," except a difference in the verbal training of the persons making the statements. There is no difference between the verbal responses, "I see your arm moving" and "I feel my arm moving," except a dissimilarity in the source of the stimulation. All statements may be regarded as physiological responses to physical stimuli.

C. The Error of Assuming that Mental Processes Are Capable of Description.

If the law of the conservation of energy is valid, if the findings from physiological investigation are sound, the non-physical or mental cannot cause a physical response. Since verbal responses called introspections are physical, they must have a physical cause, just as there must be a physical cause of other

forms of response. Since the non-physical cannot lead to description, it is unknowable and non-investigable even if it exists.

The structuralist believes that the law of the conservation of energy is true. He assumes that the mental and physical are not casually related, that they are either parallel phenomena or are two aspects of one deeper underlying reality. But in the face of this asserted belief he continues on the theory that mental experiences can lead to physical reports. Titchener, for example, says, "A train of mental phenomena may be guided and directed by events occurring within the nervous system. . . ." ⁴

D. The Law of Parsimony.

In science the explanation which makes the fewest assumptions is given preference. If behavior can be studied without reference to the non-physical, and if the data of the introspectionists can be explained without postulating mental processes, the need for assuming the mental disappears.

THE CONTRIBUTIONS OF STRUCTURALISTIC PSYCHOLOGISTS

Our refusal to follow the structuralist in his postulation of mental processes should not be taken as a failure to appreciate his contributions. He has been indirectly interested in physiological responses which have been our primary interest. This indirect interest has led him to make many investigations of direct interest to us. Further, with his direct interest in what is conceived to be mental processes he has thoroughly and in an admirably scientific manner analyzed and described the world as it appears to man through his unaided sense organs. If this task of description and analysis were the whole of psychology, the assumption of mental processes would be as good a working hypothesis as would be a set of assumptions ignoring the mental. The conception of psychology adopted in this book is, however, broader. In consequence we laid down in Chapter 2 the set of principles or hypotheses which seemed best calculated to lead us into the discovery of significant material from our point of view. The test of our set has been its adequacy in guiding us into an

⁴ *A Beginner's Psychology*, page 18.

understanding of that behavior which is socially significant and we believe that the set meets this test. It allows us to understand sensations, perceptions, and images and other socially significant responses of man. To us an introspection is more comprehensible as a description of the physical world than it is as a description of mental processes, and descriptions made in the absence of the stimulations described are more intelligible as conditioned verbal responses than they are as description of mental images.

DIFFERENCES BETWEEN ORGANISMIC DISCRIMINATION AND SPECIFICITY OF RESPONSES IN INORGANIC THINGS

If discriminations are bio-physical responses, the question arises as to why we so commonly speak of discrimination in man and animals, and not in inorganic things. The camera is affected in specific ways by appropriate patterns of light rays, and yet we do not say that it sees. The thermometer is affected in a definite way by a given temperature, yet we do not say that it feels heat and cold. The difference lies in the fact that we regard the responses of an organism not merely as responses but as responses having consequences of importance to the organism, as responses serving purposes. As we said in Chapter 2, we study organismic responses in their bio-social as well as their bio-physical aspects. In considering discriminations up to this point, we have been interested only in the bio-physical analyses. There is also the other aspect of discriminations. They are useful, and discriminations have not been fully described until this usefulness is depicted. The fast-approaching train affects a camera in a way different from a stationary train, but the difference in the response means nothing to the camera itself, the response does not preserve the camera from destruction as an animal's responses safeguard him. A thermometer is affected by the heat of a fire, but it does not remove itself from the heat; its response has no significant consequence to the thermometer. Animals make reactions that counter the effects of the excitant, they react back upon their environment. Stimulation affects

the animal, and his response in turn modifies the stimulation. His reaction is as much the resultant of the nature of the stimulus and the character of his construction as is that of inorganic things, but the consequences are markedly different. His behavior is an active adjustment to his environment, involving a modification of the environment to his advantage. His survival is made possible under a multitude of environmental conditions, for he has in his action repertoire modes of behavior that are appropriate from the standpoint of his well-being.

It seems safe to say that the construction which permits appropriate responses to the greatest number and variety of stimulating conditions is the one most likely to survive. There are inorganic objects that are highly sensitive to light rays, others that will readily react to minute sound waves, but there is no one non-living structure that approaches living things in the range of sensitivity, and, as pointed out above, the reactions of such structures possess little or no significance to the structure itself. With respect to the variety of things to which reaction may be made, man stands distinctly at the top of the animal scale. Some lower animals possess keen vision, some an acute sense of smell, others keen hearing, but none possess acuteness in all sense fields comparable to that of man. This advantage is readily apparent in considering the number of simple stimuli to which he may respond.

SUMMARY

A large proportion of our behavior is implicit. Its covertness is sometimes due to the simultaneous presence of inhibiting stimuli and more often to the execution of substitutive responses which are adequate for immediate adjustment. The implicit response is specific for each stimulation and has been developed through conditioning. It is to be regarded as physiological rather than non-physical. Organismic discriminations differ from the specific responses of inorganic things not in fundamental nature but rather in consequences; our responses contribute to our adjustment.

QUESTIONS AND EXERCISES

1. Using Hunter's delayed reaction experiment as a basis, discuss the following statements: The ability to make a substitute response sets man off most distinctly from other mammals. We think with our whole bodies. Our thoughts guide our overt actions.

2. It has repeatedly been demonstrated that an untrained animal learns little or nothing by being allowed to watch a trained one perform. Discuss the reason for this and for the fact that man is able to profit by observation of another's action. Draw from your discussion a definition of observation.

3. Why do we, when describing some familiar scene, say that we are describing our image of the scene rather than say that we are describing the scene?

4. Discuss the relation of discriminative and analytical powers.

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CHAPTER 16

ATTENTION AND CHOICE

Each year the Grand Canyon is viewed by thousands of tourists. The artist sees its beauty of coloring and grace of contour; the geologist finds in it a pictorial history of the period from the Archeozoic to the Paleozoic Age; the mystic perceives it as an awe-inspiring revelation of God's handiwork; to the farmer, it is a barren waste. All are in the same external situation, yet each reacts only to particular aspects of his surroundings. Each selects the things to which response is made. The question arises as to how we may account for this selective characteristic of behavior. Is it to be accounted for in terms of will power, power of concentration, the faculty of attention, or are these merely names for the fact that behavior is selective? Should we not expect to find the true explanation in the nature of the individual's neural organization as it had been determined by past conditioning? In Chapter 2 we laid down the principle that the nature of construction determines which stimulations will be effective in eliciting responses. In the present chapter our problem is to demonstrate its adequacy in accounting for such differences as those displayed in the behavior of the geologist and of the artist, for the fact that of the many aspects of a situation a person at a particular time reacts or attends predominantly to only one.

SELECTION IN THE INORGANIC WORLD

In inorganic substances and objects a selective characteristic is found. One chemical in the presence of many others will interact only with special ones. The radio-receiving apparatus at a given setting of the dials will be influenced by ether waves of only a definite frequency (or wave length). Montraville

Wood made a torpedo which was capable of being set into operation by certain pitches and not by others and which always turned in the direction of the effective sound. Illustrations of this sort could be multiplied almost without end, for every physical object is fundamentally selective in its reactivity. Two inorganic substances in the same environment respond to different components of that environment. Yet we never speak of their attending or concentrating.

SELECTION OF STIMULI BY MAN (ATTENTION)

As far as the author can see, the difference between selection by inorganic substances and by man is one of degree. There are, however, characteristics of man's selection that account for a seeming difference. These will be discussed under headings A, B, and C.

A. Selection as It Varies from Time to Time.

A person reacts to one component of his surroundings at one time and later under approximately duplicate conditions makes different reactions or in an unchanging situation reacts to various elements in succession. Something has happened similar to the adjustment of the tuning dials on a radio set. By means of the dials one is enabled to cause the set to select from many programs the one desired so that in the course of an evening several programs may be received in succession, or a program on one wave length may be tuned in one evening and one on another the next evening. Our sensori-motor apparatus is being continuously modified so that our sensitivity varies from time to time. These modifications are effected by our environment just as the changes in the radio set are produced by something in its environment. Suppose that a student is accustomed to work in a room where quarter-hour chimes may be heard. His study, we will suppose, is not interrupted by the bells. One day just as the chimes are ringing, a brutal murder is committed in his presence. Subsequently the chimes disrupt his studying because of the occurrence in which the ringing was an associated stimulus. This event has retuned his sensori-motor

apparatus precisely as a person retunes a radio set. The change in the potency of any stimulus for calling forth a marked reaction is a matter of conditioning. The individual becomes positively adapted to some stimulations and negatively adapted to others, as we explained in Part Two.

B. Selection as It Varies from Individual to Individual.

Each visitor at the Grand Canyon has come to be the person he is, sensitive to definite aspects of the scene, through a sequence of circumstances more or less peculiar to himself. By looking at him, we cannot say which phase of his surroundings will demand his attention. We cannot point to any external indicators of which stimuli will be effective, phrenology and physiognomy to the contrary. It is necessary under these conditions to attribute differences between persons to some unseen peculiarity. When we concern ourselves with the nature of this hidden factor, we naturally suppose that it must be fundamentally unlike the things we can see, that it must be non-physical in character, instead of assuming that it lies in the fine physical structure which is hidden from direct view. The illogicalness of assuming that the invisible is fundamentally unlike the visible is obvious. Yet, as we have said, this is the manner of reasoning pursued in all cases by primitive men. All natural phenomena were "explained" by attributing them to the control of spirits, good or evil. The factors entering into these happenings could not be seen, and consequently, primitive man conceived them as spirits or non-physical forces. The assignment of cause to these forces only directs effort away from finding the true cause. When we say that a person reacts to particular stimuli because of his power of attention, we do the same thing that primitive man did in the explanation of the behavior of inanimate things, and in so doing we direct effort away from finding the true explanation. We continue in popular speech to refer the characteristics of human behavior to hidden spirits, to non-physical forces, because the characteristics of the human reactive equipment or man's sensori-neural-motor

system are less fully known, due to exceeding complexity and difficulty of investigation. Physiological science is, however, making rapid strides, and in consequence the physical nature of man's hidden characteristics is coming to be more fully recognized. In this book we are making the assumption that as more is learned, the need for covering our ignorance by talking of mysterious non-physical factors will be lessened, that the characteristics hidden from our direct view are essentially like, not unlike, those directly observable. Let us review some of the structural characteristics that account for selection as exhibited in men in contrast to selection as exhibited in inanimate things.

In Part One we were concerned with presenting the following conceptions of organismic structure: (1) that organisms are continuously active chemical systems, (2) that there are different rates of activity in the various regions, (3) that regions of high activity dominate those of lower activity, (4) that at any instant there is a pattern of dominance and subordination, (5) that stimulation serves to raise the rate of activity in the region affected and consequently to make it the dominant region, and (6) that the stimulation-imposed pattern modifies the more permanent pattern. These characteristics are not revealed when we see a person before us but rather are discovered through physiological research. If we recognize their validity, we find in them an explanation of selection as exhibited by man.

C. Selection of a Single Component.

In reviewing these structural characteristics, the basis for another difference between animate and inanimate selection is found. Organismic structure is such that the response to one stimulus temporarily dominates the activity of the whole organism. While reacting to one stimulation, a person is relatively immune to other excitants. While one is reading a novel, rain may beat upon the window unheeded. An amoeba having sent out a pseudopod toward one piece of food tends to disregard others.

A dog scratching his shoulder in response to a flea bite does not raise his other hind leg in response to pain stimulation applied to the sole of this foot as he would do when not engaged in scratching. This does not mean that the second stimulation has no effect but only that the response appropriate to one stimulus is made to the exclusion of responses appropriate to other stimuli. The noxious stimulation to the sole of one of the dog's feet lessens the vigor of scratching. If made intense it gains ascendancy, causing the scratching to cease and the foot to be lifted. The response appropriate to one stimulus or the other is made, but not to both at once. The beating of the rain interferes with novel reading even though it is unnoticed. If it becomes severe, it may gain ascendancy and lead the reader to make sure the windows are closed or to make a remark about the weather. When it attracts notice, novel reading ceases for the instant. This fact that organismic response at any time is appropriate to but one stimulus stands in contrast to the response of objects acted upon by two forces. If two cords are attached to a ball and both are pulled, one to the east and the other to the north, the ball is moved to the northeast rather than in one of the two directions. The effect of two forces on an inanimate object is to produce motion which is a resultant of the movements that would be produced by each force acting by itself. If the two forces are equal and opposite in direction, no movement occurs. The effect of two stimuli applied to an organism is a response appropriate to one or the other. If an animal is equidistant from two like sources of food, he goes to one or the other.

This characteristic we attributed in Chapter 4 to the stimulus-imposed pattern. The amoeba having sent out a pseudopod is for the time a special amoeba. A person absorbed in a novel is during that period a being which he is not at any other time. The runner immediately after the "ready" signal is a person different from the one he was before. In other words, man is not merely a structure but a continuously changing one. He is at one time John Jones absorbed in a novel and at another

John Jones set to run a race. Having finished his race or his novel, he is a permanently different structure, retaining a sufficient number of his peculiar traits to set him off from Tom Smith.

SELECTION OF RESPONSE TO BE MADE (CHOICE)

A. Selection without Delay.

Akin to the fact that we react to the stimulation which is for our present structure most potent is the fact that in our repertoire of acts we have several possible responses to an excitant, and of these at a given moment we choose only one. We react to the visual stimuli arising from a magazine now by reading it, now by crumpling its pages for kindling a fire.

This variability is in large part to be accounted for by the situation in which the excitant occurs. The importance of the background has been frequently mentioned. The confusion which arises from speaking of reactions as if determined by a single element of the environment instead of by that element in its setting is apparent. A magazine on our library table leads to a different response from that of the same magazine on a shelf in our basement. The reaction is to be referred to the magazine only because without it the acts of reading or crumpling would not have been performed.

In addition to this variation of the background in which excitants occur is the change in the person himself from the time the excitant appears until it reappears. Suppose you have a friend whose first name is James. The mention of the name causes you to think of this friend. After you have spent several hours looking up the biography and works of William James, the word leads you to think of him rather than of your friend. The change is in you, not in the word.

When several responses have been attached to one stimulus, the one chosen depends upon the present relative strength of the linkages. Reviewing the conditioned reflex principles, we find that the amount of conditioning depends upon: (1) the frequency of instances in which the stimulus has preceded the

response in question, (2) the recency of these instances, and (3) the dominance or intensity of the reaction. One response may have occurred more frequently than another, but the linkage with the other may be stronger because of its recency. Consequently even though we know the situation in which the stimulus is encountered, we cannot predict what response will be made unless we know the life history of the person. No one can fully recall his own history and so no one of us is capable even of predicting his own behavior, a fact which makes it seem that responses are capricious and not amenable to law. As long as men are not omniscient, behavior will remain to some degree unpredictable, but this does not mean that it may not be understood and to a large extent controlled.

B. Selection with Delay (Deciding).

Thus far we have taken the stand that of the many present stimuli the appropriate response is made to but one, and that of the many possible reactions one is made on the basis of the nature of the total stimulation and the physiological characteristics of the organism at the time of excitation. In many instances two stimuli which ordinarily lead to incompatible responses are active, and an overt response is made to one or the other only after considerable delay. What happens in this period, and what finally leads to the making of one of the responses?

1. *Decision on the basis of foreseen consequences.* We may have a lesson to study and an invitation to go to the movies. We deliberate as to which we shall do. In this period both responses, studying and going to the movies, are made substitutively. As they are performed in this manner, their consequences are observed. If a host of undesirable consequences lie in the wake of failure to do one of the alternatives, the decision is readily reached. If failure to study means "flunking" an important examination, failure in the course and dismissal from school, the student has no difficulty in deciding to study rather than go to the movies. On other occasions the consequences

of going to class unprepared may not be serious and the invitation may be from a highly valued friend, so the decision is the reverse.

In many cases the consequences attached to each of the alternatives are more equally balanced in importance. The student may be as certain that he should study as he is that he would like to go to the movies. He cannot come to a decision. When the time to start to the movies arrives, he goes. Two things account for this. In the first place there is a definite time linked with one response and not with the other. The arrival of this time throws the balance in favor of the response associated with it. In the second place undesirable consequences usually seem less certain to follow than desirable ones. The student reasons that there is a possibility of not being detected in his lack of preparation and that even in case of a failure in class there is a chance that his mark will not be appreciably affected. In going to the movies, he is sure to have a good time. These two factors often influence the decision. If a person is offered two equally attractive positions, he will in all probability accept the one requiring immediate acceptance. The time for action arrives, and he decides in favor of the one which is most closely linked with that time.

Because of the apparent certainty of desirable consequences one often decides to do the thing desired and then finds reasons to justify his decision. This justification of a decision made or of an act already committed is known as rationalization.

2. *Decision on the basis of guidance by "conscience."* Often reasoning enters into neither the making nor the justification of a decision. The person says that he feels he should or should not do a certain thing. When asked why he feels as he does, the reply is likely to be, "I just feel that it would be wrong," "My conscience will not let me do it," "My sense of honor (or duty) requires it." These statements describe the results of training in which reasons have not been given. The child's conscience tells him not to take cookies after he has been punished for having done so. Similarly there is developed in

him a conscience which tells him that he must permit other children to play with his toys and that he must keep his promises. The child who has not been taught to abstain from theft has no scruples against stealing. The cannibal's conscience does not forbid him to eat his fellow man; he has had no training to stamp out the practice. The individual who has not been taught to be honest has no sense of honesty or dishonesty.

When the child is punished for sins of omission or commission, he is told that what he did was wrong. A rebuke in conjunction with punishment makes scolding a substitute for punishment in case of later demeanors. Subsequently when he encounters situations similar to those in which he has been reprimanded, he reacts as if the censor were present and is led to say without being reminded by a disciplinarian that his contemplated act would be wrong. He reacts to a non-personal situation as if persons were present, just as the dog reacts to eggs as if they all contained pepper. This influence of persons in their absence is what we term the influence of conscience. Our ideas of right and wrong are our verbalizations of what we have found to bear the stamp of the group's approval or disapproval.

When we have been reared in a home or community in which card playing has been condemned and then become a member of a group where it is sanctioned, we may disregard our early training and yield to the new influences. We say that our conscience troubles us for having acquiesced. We have acted in a way that has customarily incurred disapproval, and we still expect it and live in dread of it. If it is not forthcoming, we soon become reconditioned; our conscience has been dulled.

Conscience is not a non-physical force which settles our conflicts. Rather the word describes the influence of modifications that have been produced during a long period of social training. We cannot see those modifications nor recall all the training that was involved in producing them. We can, however, observe their influence, and to the invisible factors involved we give the name, conscience.

3. *Decision on the basis of a loyalty to a group or cause.* When there is a conflict as to what to do, it may be resolved in still another fashion. Some code of conduct laid down by a special group of which one is a member may be brought to bear on the situation. There is a code for marine officers which is adhered to in case of shipwreck, and although punishment for disobeying the code would be unlikely, the captain's impulse to save himself is checked by the thought, "The ship's captain is the last man to leave the boat."

Each of us is loyal to the code of some school, fraternal order, church, or other organization. If devoted to our group or to its founder, we have but to ask ourselves, "What would a Christian or Christ do in this situation?" "How would a true American behave under these circumstances?" It is often surprising to parents to find that their sons will as scouts do things which parental persuasion has never induced them to do. Happy is the man who is loyal to some group or cause, for his choices are dictated and he need only carry them out. Moreover he has a set of values that enhance his accomplishments, for the value of his act is not measured by benefit to himself but by gain to the cause. Even though a person does not adopt the code of a group, he develops a set of principles of his own and becomes loyal to them, achieving through that loyalty the same results that he would achieve through group loyalty. In a subsequent chapter we shall discuss the development of ideals and purposes.

C. Vacillation.

After a decision has been reached verbally, we may still waver. It is in these periods of vacillation that the force of will is popularly supposed to enter and carry us through in conformity with our decision. The child may want a cookie while his parents are away. He remembers that he has been told not to take cookies, possibly recalls chastisement for having disobeyed, and finally decides not to take a cookie. But presently the desire for one arises with renewed vigor, and he begins to reason

that there could be little harm in satisfying his hunger. He starts toward the cookie jar but checks himself with, "No, I will not." Why does this verbal response occur with its accompanying avoidance? It will be remembered that as the approach takes place the avoidance stimuli become more effective. We observed in the case of the dog whose egg has been treated with pepper but once, that the avoidance was not set off until he was just on the point of eating another egg. The baby who has been burned in a flame almost touches another flame before withdrawing. A horse confronted by a strange object approaches and when near suddenly turns in fright, then returns and again retreats. The child's approach to the cookies with the subsequent retreat is analogous. Will power, then, describes the fact that situations arouse in a person the verbal responses which he has heard applied to like situations and that these inhibit or reinforce acts in progress.

If a child takes cookies when he knows that he should not, his verbal responses come to have little influence upon his overt behavior. His will power will be weak. If he is to have a strong will, he must not only be taught to make the proper verbal response, but care must be taken to insure overt behavior in conformity with the verbal response made. In other words no inconsistency between what is told and what is required can be permitted. This insures the prosecution of any verbal decision regardless of the manner in which the decision is reached. A person who finds himself characterized by vacillation should take pains to carry through his decisions even though he is not certain of their justification.

RESPONSIBILITY

If this treatment of choice is sound, if the choice made depends upon present circumstances and present structure and if present structure depends upon the nature of the germ plasm and the environmental conditions that have affected the person up to the present, the question arises as to the sense in which the person is to be held responsible for his acts.

A. Responsibility as Implied in the Legal System.

Legally the insane and feeble-minded are not held responsible for criminal acts. It is recognized that they could not have been trained to do differently and are of such a constitution that they could not be retrained. A person is held responsible for his acts only when he gives evidence of being amenable to training. To take the attitude that a normal individual is responsible for his conduct is in itself a large factor in modifying his behavior. He is sensitive to approval and disapproval, and his manner of living is modified accordingly. In bestowing blame or praise, we are implicitly assuming that the person is not free to disregard it.

B. Responsibility as Implied in Our Educational Systems.

All educational systems assume that by bringing the proper influences to bear, we can modify the pupil in the direction desired by society. This, of course, does not mean that the individual is a *tabula rasa* upon which we can write at will, a plastic piece of clay that can be moulded to pattern. Various influences have been writing, been moulding, been modifying since conception and have produced a construction which sets bounds to further modification. All we can do is to work from the existing structure—to educe its potentialities. In doing this, we assume that a person's past has determined what his present is, that his present determines what his future is to be, and that we, by interposing ourselves and a set of influences which we bring with us into his present, become a contributing determiner of his future.

When a person is told that he is free to become what he chooses, he is more technically being told that persons constructed as he is have proved the possibility of becoming men of this or that type and that consequently there is the possibility that he, too, may attain their standing. After being told this, he attempts to ascertain what they did and then to mould his own conduct accordingly, thereby increasing the chance of becoming what they became.

QUESTIONS AND EXERCISES

1. Compare the concepts of stimulus-potency and stimulus-intensity. How is stimulus-intensity measured? Stimulus-potency? Is there any correlation between the two? How do you explain the correlation or the absence of correlation? Can you think of any misconceptions developed from confusing the two?

2. In Chapter 3 it was said that the amoeba does have self-control but that the self is a complex and intricate physical structure. Can the same be said of man?

3. As we become older, things come to possess different meanings than they had when we were younger. As we change the world changes. This suggests that the world might be conceived as subjective instead of objective. How far are you willing to follow the suggestion?

4. On which of the three bases discussed in the chapter is a decision most likely to be right? What is meant by right? On which basis will momentary impulse be less likely to issue in action?

5. To what extent is an individual free from social influences in making his decisions? What is individual freedom? Who is most free? How is the greatest freedom to be attained?

6. Is punishment which does not correct ever justified? What proportion of punishment is corrective?

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CHAPTER 17

INDIVIDUAL DIFFERENCES

Most of us develop manipulative skills; we learn to talk, read, write, and calculate; we come to possess wants and to hold to ideals; we become capable of making discriminations and choices. Yet each of us is different from everyone else. Peculiar to each of us is a neuro-muscular organization which is responsible for an individuality evidenced in the sort of skills, wants, and ideals possessed, in the efficiency with which tasks are performed, in the acuteness of discrimination, and in the quality of decisions made. Our problem now is to consider how extensive these differences are, what their nature is, how they come about, and how one difference is related to others.

THE EXTENT OF INDIVIDUAL DIFFERENCES

In every case in which a trait, an ability, or a characteristic of behavior has been measured in a large number of individuals, a great deal of variation from person to person has been found. This is true also when a characteristic of structure is measured, whether it be a gross characteristic such as height, or weight, or volume of body, or a minor one such as length of the forefinger, head girth, or diameter of the hairs of the head.

If the measures of one characteristic are cast into a table in such a manner that the number of individuals possessing each amount is shown, the resulting table is known as a distribution table. If the results are plotted, the plot is called a distribution plot. It is quite generally found in distribution tables and plots that the number of persons possessing an amount near the average are much more numerous than those possessing a small or a large amount of the characteristic. The average student is more common than the bright or dull one. This is

shown repeatedly in quizzes and examinations. Table 3 shows the distribution resulting when a true-false quiz was given a

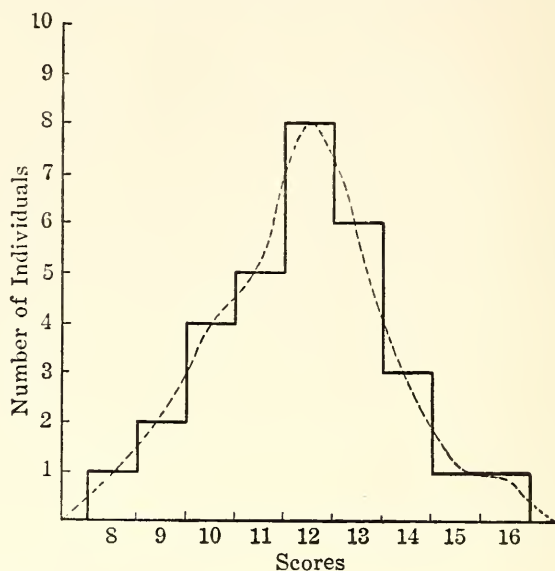


FIG. 35.—The distribution plot of scores made by a class of 35 on a true-false test. Sometimes plots are made as shown by the unbroken line and sometimes as shown by the dotted line.

class of 35. Figure 35 is the plot made from the table. Figures 36 and 37 give the plots obtained from measuring two character-

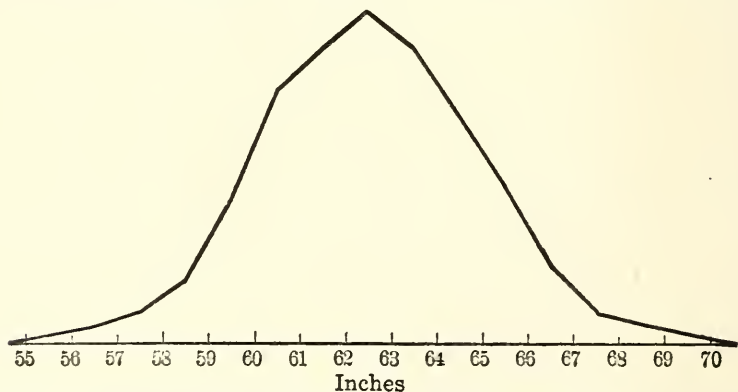


FIG. 36.—Distribution of the height of 1052 women. (From Starch.)

istics of structure. Figure 38 gives the distribution plots of six behavior characteristics.

TABLE 3

DISTRIBUTION TABLE OF SCORES MADE ON A TRUE-FALSE QUIZ

SCORE	NO. OF INDIVIDUALS
16	1
15	1
14	3
13	8
12	9
11	6
10	4
9	2
8	1

The similarity of these plots will be noted. All approximate a bell-shape. Mathematicians have calculated a theoretical dis-

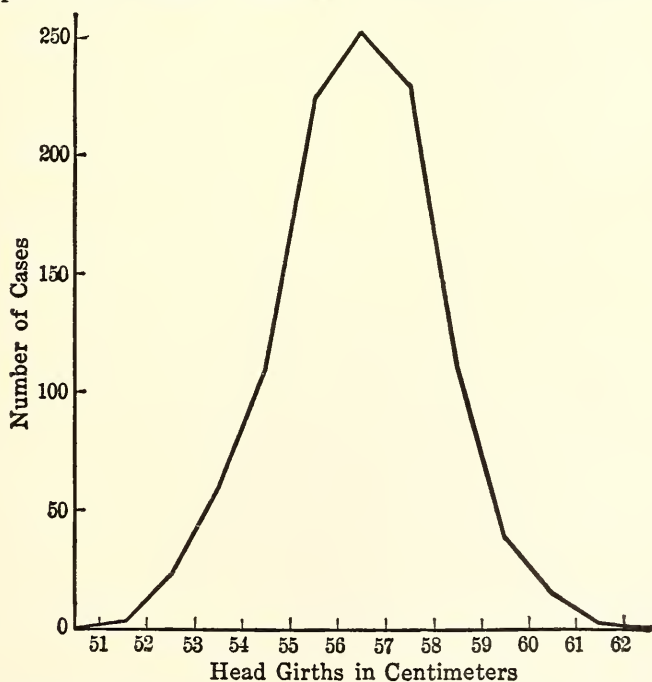


FIG. 37.—Distribution of the head girth of 1071 boys, 16-19 years of age. (From Starch.)

tribution and find it to be a perfectly symmetrical bell-shaped curve. If the extreme ends of the curve are disregarded because

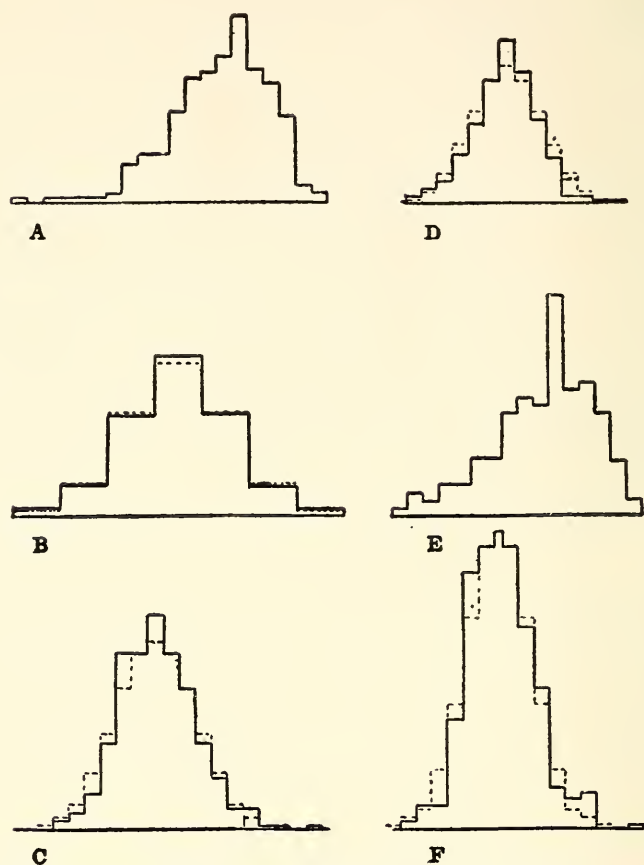


FIG. 38.—Samples of the forms of distribution found in mental traits.

A. Reaction time: 252 college freshmen.

B. Memory of digits: 123 women students.

C. Efficiency in marking A's on a sheet of printed capitals: 312 boys from 12 years 0 months to 13 years 0 months.

D. Efficiency in giving the opposites of words: 239 boys from 12 years 0 months to 13 years 0 months.

E. Accuracy in drawing lines to equal a 100 mm. line: 153 girls from 13 years 0 months to 16 years 0 months.

F. Efficiency in marking words containing each the two letters a and t: 312 boys from 12 years 0 months to 13 years 0 months.

In all six cases the left end of the scale represents the lowest abilities—that is, the longest times in A, the fewest digits in B, etc. The continuous lines give the distributions. The broken lines show theoretically symmetrical distributions. (From Thorndike.)

of their closeness to the base line, and if the remainder of the base line is divided into five equal divisions, the proportion of the area above each division is that shown in Figure 39. This theoretical curve supported by empirical findings is at the basis of the marking system followed in most high schools and colleges. About 3 per cent of the students do and theoretically should receive the mark of "A," about 22 per cent one of "B," etc. The theoretical curve shows what would probably

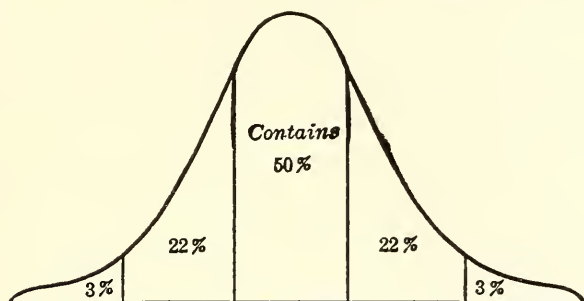


FIG. 39.—The theoretical distribution curve with the extreme ends omitted and the remaining base line divided into five parts. (From Gates.)

be found in any trait if accurate and extensive measurement could be made.

If a thousand persons selected at random were measured for their ability to read Greek, the usual curve would not be secured. Rather, the great majority would be found to have zero ability. Excluding these, the plot for the remainder would, however, approximate a bell-shape. In general it may be said that the normal distribution is not found when one factor is dominant in determining the ability but is found when many factors contribute to its determination.

THE NATURE OF INDIVIDUAL DIFFERENCES

It is apparent from the nature of the distributions found in measuring abilities that all differences may be regarded as quantitative rather than qualitative. Individual A may possess very high ability in mathematics, average ability in other school subjects, average ability in making friends, and zero ability in

running a lathe; while B may have a very high ability in running a lathe, very low ability in school subjects, and more

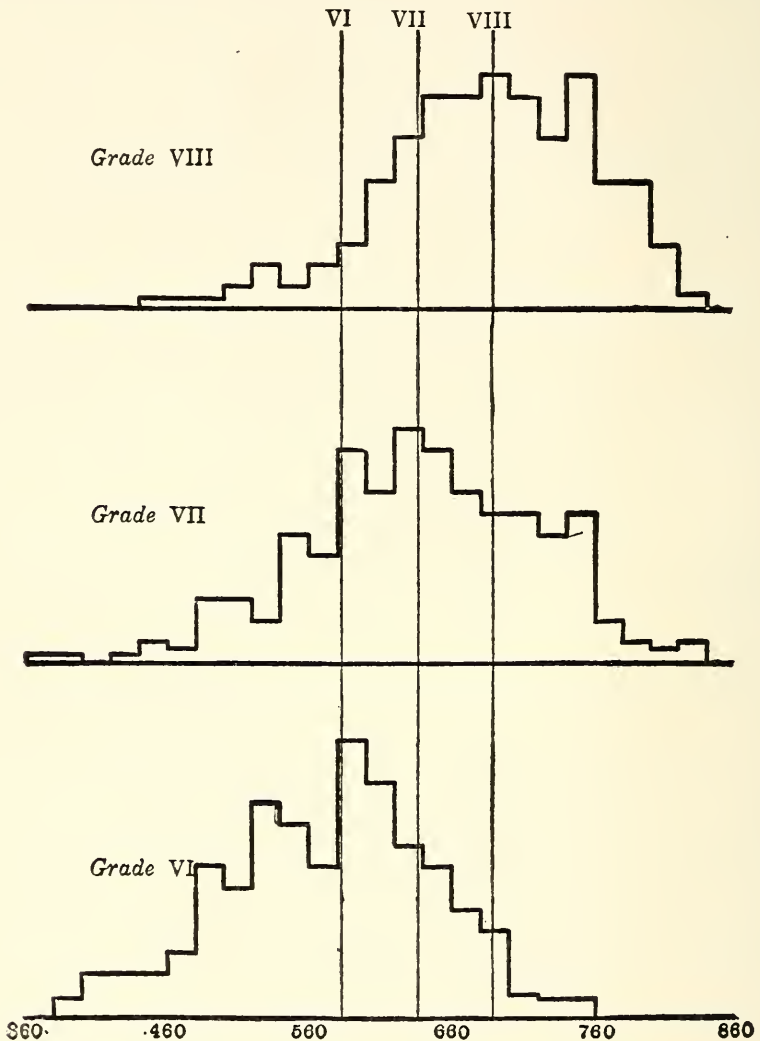


FIG. 40.—Distribution plots for composite scores in 22 different mental and educational tests. There are 254 pupils in the Grade VI group, 324 in Grade VII, and 282 in Grade VIII. (After Kruse and Gates.)

than average ability in making friends. The two would strike us as quite different in their qualitative make-up; one we would call a mathematician and the other a mechanic, yet

basically their differences are quantitative. Each ability of either of them may be represented at some point along the base line of the distribution plot for that ability, represented as above or below average, as plus or minus.

Since there are no breaks in the distribution curve, it follows that any division into groups is arbitrary. There is no "A" student as distinct from a "B" student; there is no expert mechanic as distinct from an apprentice; there is no feeble-minded person as distinct from a normal person. Figure 40 shows clearly that there is no sixth-grade child as distinct from a seventh-grade one. As Chapman and Counts¹ remark, "The only type which can be postulated is the hypothetical average, commonplace, mediocre human from which every individual diverges to a greater or less extent."

THE CONDITIONS UNDER WHICH A BELL-SHAPED DISTRIBUTION OCCURS

The bell-shaped curve is often termed the chance distribution curve since theoretically and actually *it is the outcome when a number of independent causes or variables are operative together on a number of occasions to produce one composite result*. If one were to shake a thousand pennies in a large box and keep a record of the number of heads appearing on many successive trials, the outcome would be represented by a bell-shaped curve. Each penny may be considered an independent variable because in each case the head or the tail may come up. The outcome of a single toss is a composite result since one measure of all possible results, the number of heads, is used. Only once in several thousand times would all heads be turned up or would no heads appear, while there would often be 498, 499, 500, 501, 502 heads. In fact, there would be between 458 and 542 heads in fifty per cent of the tosses, just as fifty per cent of people when measured for one characteristic fall in the middle division of the theoretical curve divided into five areas. The deduction is that each person's ability in any one task is the result of a great

¹ *Principles of Education*, page 185.

number of factors, independent variables. Each person represents one of nature's tosses. Seldom do nature's variables combine to produce an eminently superior individual or to produce a markedly deficient individual; seldom does a toss of nature result in the appearance of all heads or in the appearance of no heads.

INDIVIDUAL DIFFERENCES IN RELATION TO HEREDITY AND ENVIRONMENT

In Chapter 4 we discussed the influence of chromosomes and the continuous action of environment in determining what a given person shall be. The outcome of the fertilization of an ovum is a unique germ cell, one in which specific chromosomes are present in a definite arrangement. The result of the union of a sperm and ovum cannot be predicted since, as we have seen, there are billions of possibilities, just as the result from one toss of a thousand pennies cannot be predicted. After the ovum is fertilized, the many influences of environment are operative in determining the line of development that is taken.

It will be recalled that we concluded in Part One that hereditary and environmental influences cannot be separated. If two individuals differ in any way, the difference may be referred to inheritance only if it is assumed that both have had the same environment. The question of whether any difference is to be referred to inheritance resolves itself into the question of whether one is willing to assume a normal and uniform environment. On the other hand, if two individuals are alike in any respect, the similarity may be referred to inheritance only if the opposite assumption be made, only if it be assumed that the two persons have not developed under the same environment. It seems impossible to justify either of these assumptions, and consequently all that can be said is that individuals differ because they have different inheritances and different environments.

FAMILY RESEMBLANCES

Aside from the question of the causes of resemblances and differences, it is interesting to know to what extent relatives are

different and alike in abilities. This may be determined by finding the mathematical coefficient of correlation. A coefficient of 1.00 indicates perfect similarity, one of 0 indicates as much similarity as difference, and one of -1.00 indicates the extreme of dissimilarity. It may be re-emphasized that the extent of correlation indicates nothing with reference to causes.

The coefficients of correlation for general ability as measured by intelligence tests are as follows:

Parents and offspring	.30
Siblings	.52
Unlike-sexed twins	.50
All twins	.78
Like-sexed twins	.89

A correlation of 1.00 would mean that the child was exactly like his parent in the trait measured, or exactly like his brother or sister, while a correlation of .00 would mean that he resembles his parent or brother no more closely than anyone else chosen at random. The correlations found indicate that he does resemble his close relatives more than persons chosen at random, and that he also differs from them to a marked extent.

The correlations for other abilities are approximately the same as those for intelligence. Thorndike found the following coefficients of correlation in ability to perform the three tests named below.

<i>Test</i>	<i>Twins</i>	<i>Siblings</i>
A-test	.69	.32
a-t and r-e test	.71	.29
Opposites	.90	.30

The A-test is a test of the rapidity and accuracy in cancelling A's from printed material; the a-t and r-e are tests of the rapidity and accuracy in cancelling words containing a and t or r and e from a list of printed words; and the opposites is a test of the ability in naming the opposites of increasingly difficult words. Thorndike and others have determined many other correlations and find them to have values very nearly the same as these. See Thorndike, E. L., *Educational Psychology*, Volume 3, Chapter 11.

These correlations in ability are approximately the same as the correlations for structural features. According to Pearson, the coefficients of correlation for height in brothers is .50, in father and son .30, and for color of eyes in brothers .52. In other words, near relatives resemble each other equally in abilities and in structure.

THE INTER-CORRELATIONS OF ABILITIES

If a person possesses a high degree of one ability, the question arises as to whether he is likely to possess a high degree of others. In the field of education it may be asked whether an "A" student in one course is commonly an outstanding student in another. This can be best answered by determining the mathematical correlation between abilities. In making this determination, the marks made in two courses, for example, languages and mathematics, by a large and representative group of students are secured. By a mathematical procedure which need not be described, the amount of correlation between abilities in the two subjects is determined. If all "A" students in languages were "A" students in mathematics, all "B" students in the former "B" students in the latter, etc., the value of the derived correlation would be 1.00. If all "A" students in languages were "E" students in mathematics, all "B" students in one subject were "D" students in the other, etc., the value would be -1.00. If the "A" students in languages were distributed normally, *i.e.* according to the bell-shaped curve, throughout the range of marks in mathematics, the "B" students in languages likewise distributed, etc., the value would be .00. Investigation reveals that the correlations of abilities in school subjects are positive and relatively high, *i.e.* a good student in one subject is commonly but not always a good student in others, a poor student in one is usually poor in all, and an average student is for the most part an average student whatever his subjects. The mathematical values for the correlations of school subjects are given in Table 4.

TABLE 4
CORRELATIONS AMONG ABILITIES IN SCHOOL SUBJECTS
(From Starch)

Arithmetic and language.....	.85
“ “ geography.....	.83
“ “ history.....	.73
“ “ reading.....	.67
“ “ spelling.....	.55
Language and geography.....	.85
“ “ history.....	.77
“ “ reading.....	.83
“ “ spelling.....	.71
Geography and history.....	.81
“ “ reading.....	.80
“ “ spelling.....	.52
History and reading.....	.67
“ “ spelling.....	.37
Reading and spelling.....	.58

In Table 5 the values for correlations of several other abilities or behavior characteristics are shown. It is readily seen from this table that the possession of a high degree of some traits

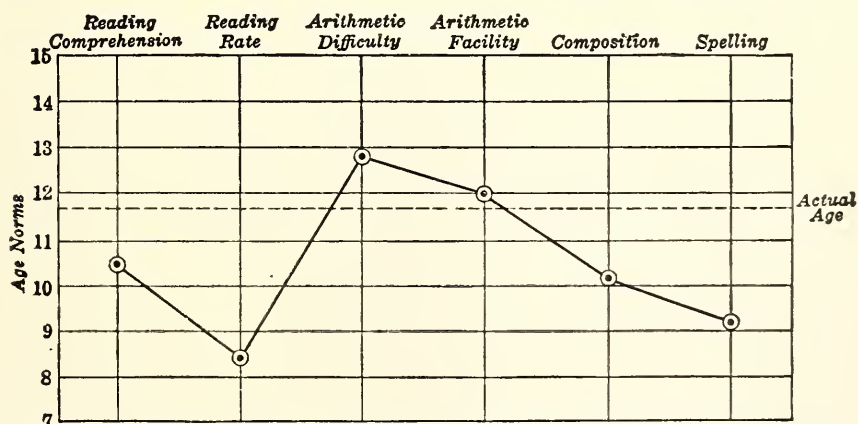


FIG. 41.—An individuality profile of one student in six educational tests. This profile shows more than average irregularity. (From Gates.)

is not paralleled by the possession of a high degree of others. If one person were measured with respect to his efficiency in various tasks, he would be found to be high in some, average

TABLE 5

CORRELATIONS AMONG ABILITIES IN SPECIFIC TESTS. (From Starch)

Decimals are omitted. The first group of values was determined by Simpson and the second by Burt.

	Ebbinghaus test	Hard opposites	Memory of words	Easy opposites	A-test	Memory of passages	Adding	Geometrical forms	Learning pairs	Completing words	Drawing lines
	1	2	3	4	5	6	7	8	9	10	11
1. Ebbinghaus test											
2. Hard opposites	92										
3. Memory of words	92	92									
4. Easy opposites	75	81	68								
5. A-test	68	76	70	71							
6. Memory of passages	91	86	89	69	60						
7. Adding	71	74	56	70	67	66					
8. Geometrical forms	54	64	67	54	94	60	44				
9. Learning pairs	72	72	82	43	44	63	46	40			
10. Completing words	50	70	51	50	84	38	77	61	34		
11. Drawing lines	26	25	06	53	27	12	27	30	04	17	
12. Estimating lengths	52	55	59	56	57	58	17	35	54	22	55

	Dotting	Spot pattern	Mirror	Memory	Alphabet	Sorting	Dealing	Tapping	Sound	Lines	Touch
	1	2	3	4	5	6	7	8	9	10	11
1. Dotting											
2. Spot pattern	71										
3. Mirror	92	75									
4. Memory	53	62	38								
5. Alphabet	84	89	63	73							
6. Sorting	87	57	67	58	91						
7. Dealing	33	53	05	12	60	54					
8. Tapping	78	57	74	40	80	89	57				
9. Sound	65	47	66	23	51	—18	17	48			
10. Lines	52	67	55	16	35	19	26	36	09		
11. Touch	30	—04	38	06	09	—06	—08	10	12	23	
12. Weight	16	18	30	14	10	—05	17	42	29	00	49

in others, and low in still others. A plot could be made which would represent his individuality. For example, the plot of Figure 41 represents the individuality of one child in his performance of six educational tests, and Figure 42 represents the individuality of another. Only very seldom would two children be found whose plots were identical for as few as six abilities, and

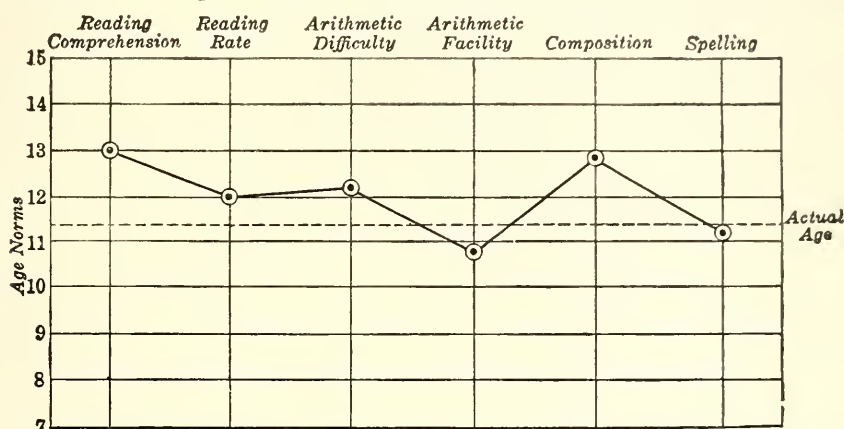


FIG. 42.—An individuality profile of another student. This profile shows about an average amount of irregularity. (From Gates.)

it is safe to say that never would two identical plots result if all measurable abilities were plotted.

When we cease considering the separate characteristics, when we do not single out a specific ability but rather view the person as a whole, as a unit, as a composite of performance abilities, we get a picture which we call his *individuality*, a picture determined by the *kinds of abilities conspicuously present or absent*. When we consider the general or average level of adjustment achieved through this composite, we speak of *intelligence*. When we limit ourselves to the *composite of characteristics socially approved or disapproved*, we speak of *personality*. The next two chapters will be devoted to individual differences when viewed in these two ways.

THE NATURE AND EXTENT OF GROUP DIFFERENCES

When instead of comparing individuals we compare groups, differences of two sorts may be found. The one group may on

the whole be higher than the other, *i.e.* the two groups may differ as represented by the two distribution curves of Figure 43. One group may differ from another also in the manner indicated in the two distribution curves of Figure 44, *i.e.* one group may have greater variations within itself than the other.

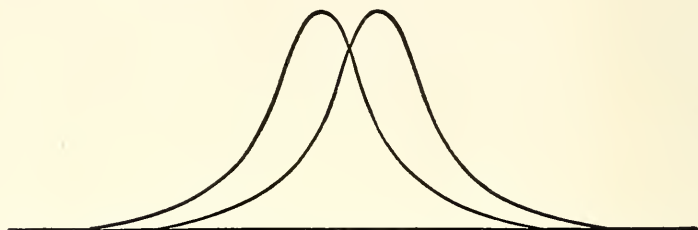


FIG. 43.—Theoretical distribution plots of two groups which differ in average ability and which scatter to the same extent.

A slight difference of the latter sort has been found to exist between the two sexes in some traits. Thorndike,² for example, found that the scores made on a battery of tests by girls of the ages nine to twelve scatter only 92 per cent as much as the scores made by boys of the same age. The difference in

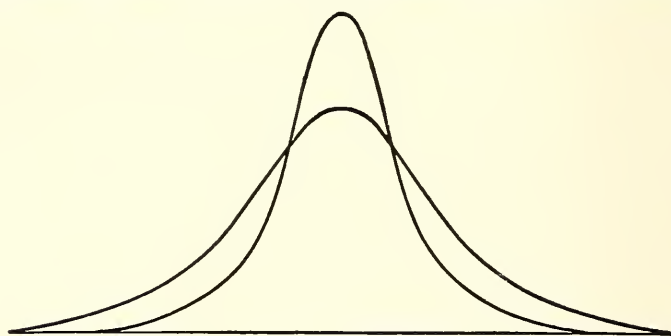


FIG. 44.—Theoretical distribution plots of two groups which have the same average ability and which differ in amount of scatter.

the height of the two sexes is a difference of the former sort, *i.e.* there is a difference in average height. Some of the differences in abilities between the two sexes are indicated in Table 6. The differences between boys and girls and between men

² *Educational Psychology*, Vol. III, page 194.

and women are, however, insignificant as compared with the differences between the individuals of either sex. A similar statement may be made with reference to the differences between races. Few significant differences in abilities

TABLE 6

DIFFERENCES IN THE ABILITIES OF THE TWO SEXES

A percentage less than 50 means that women as an average are better than men, while a percentage greater than 50 means the reverse. The values for special tests were completed by Thorndike from Woolley, those for the educational tests by Starch, and those for school marks by Thorndike.

<i>Special tests</i>	<i>Percentages of men reaching or exceeding the median of the women</i>
Reaction time.....	68
Tapping.....	81
Sorting cards, speed.....	14
Sorting cards, accuracy.....	44
Thrusting at target.....	60
Drawing lines.....	72
Threshold of pain.....	46
Threshold of taste.....	34
Threshold of smell.....	43
Lifting weights.....	66
Two-point discrimination.....	18
Memory (syllables and learning).....	32
Ingenuity.....	63
<i>Educational tests</i>	
Speed of handwriting.....	47
Quality of handwriting.....	39
Arithmetical reasoning.....	60
History.....	72
Geography.....	48
<i>School marks</i>	
	<i>High school pupils</i>
English.....	41
Mathematics.....	57
Latin.....	57
History.....	60
	<i>College students</i>
English.....	35
Mathematics.....	45
History and economics.....	56
Natural sciences.....	50
Modern languages.....	40

have ever been found in comparing races. It is only when a highly selected group is compared with an unselected one that significant differences are shown. For example, college students differ markedly from the general population in intelligence. They are on the whole much higher, and they do not vary in amount so much as people in general, but even with such a marked contrast between two groups there is much overlapping. A great number of non-college persons are as intelligent as the brightest of college students.

CONCLUSIONS

An approximately bell-shaped distribution is found for nearly all measurable abilities. Individual differences may, then, be thought of as quantitative, and classifications are to be conceived as arbitrary groupings. Many independent factors must act as contributing causes if a bell-shaped distribution is produced.

The rôle of heredity and the part played by environment in producing differences and similarities cannot be separated.

Two relatives usually resemble each other in ability more than two persons selected at random.

The coefficients of correlation of one ability with another range from $-.20$ to nearly 1.00 . Most values are positive and moderately high.

The members of a race differ from each other much more than one race differs from another. Likewise, the members of one of the sexes differ in ability much more than the two sexes differ from each other.

QUESTIONS AND EXERCISES

1. Make a note of several practices which do not take account of individual differences, *e.g.* the same course load for all students, the same wage for all members of a given trade. Give reasons for each practice.

2. Can you think of a single characteristic in which there are not marked individual differences? Can you think of two people who possess one characteristic to the same degree? Two characteristics? Three? Several? All?

3. To what extent does an examination in one subject measure scholastic ability? Ability in that subject? What proportion of abilities are measur-

able? In what sense in the rating by an acquaintance a measurement of a characteristic?

4. How does one account for the widespread belief in individual, sex, and race types? Is the belief justifiable? Defend your answer.

5. How do you account for the widespread belief that there are negative correlations for the abilities in some school subjects, *e.g.* between the ability in languages and that in mathematics?

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CHAPTER 18

INTELLIGENCE

Individuals learn at markedly different rates even when to all appearances they have an equal chance. Of course the person who learns least rapidly will in the course of his life learn least. Some are so deficient that they never learn the rudiments of successful living, and we label them feeble-minded. The lower grades of the sub-normal cannot be taught to feed and dress themselves or to protect themselves from the common dangers. From this exceedingly meagre ability to learn are all degrees up to the ability to learn how to invent, how to direct great governments, industries, and institutions, and how to discover the laws of the universe, the ability represented in our great inventors, statesmen, clergymen, captains of industry, scientists.

THE CONCEPT OF INTELLIGENCE

These differences in capacity for learning have for centuries been termed differences in amount of intelligence. The introduction of the term capacity should not prove misleading. It should not cause us to think of some entity or faculty of the mind. We speak of rubber as having a capacity for stretching. We mean only that rubber is so constituted that it stretches when pulled. When we speak of an organism as having a *capacity for learning*, we mean only that its *whole physiological nature is such that it profits by experience*. When we go further and speak of a certain degree of intelligence, we mean only that some persons (and species) do acquire more learned responses than others and that they make these acquisitions with greater rapidity. If one raises the question of why this is true, no detailed answer is forthcoming. It is like asking why water is wetter than gasoline. The only possible reply is that water is

wetter because it is wetter, which is obviously no answer at all, or that water is wetter because it possesses a molecular structure different from that of gasoline. In a like manner, all that can be said is that one organism is more intelligent than another because it possesses a sensori-neural-motor structure different from that of the less intelligent organism. The cause of high intelligence is to be sought not in some one bodily organ but rather in all the physiological features of the total organism.

Whenever a capacity is mentioned, there is an implied prediction. After stretching several rubber bands, we recognize a capacity for stretching in other bands. We are by implication predicting that others will stretch if we try them. We watch a person performing old tasks or learning new ones and recognize a certain degree of intelligence. We are by implication predicting with some surety the progress he will make in acquiring other skills. The more accurate our observation and the greater the number of occasions on which we observe, the more accurately can we judge the capacity possessed, the more accurately can we predict subsequent performance.

INTELLIGENCE TESTING

There are many circumstances under which foreknowledge of performance is a distinct advantage. The employer desires to be reasonably confident that a prospective employee will meet his requirements. The local and state governments want assurance that persons committed to institutions for the subnormal are sufficiently deficient to require institutional care at the expense of the state. The directors of these institutions need a knowledge of the extent of the deficiency in order to provide proper care. The administrators of colleges and universities want some assurance that prospective students will be able to profit by the curriculum offered. For the sake of greater effectiveness in teaching, the administrators and teachers of public schools require some manner of ascertaining the relative abilities of the students under them. The staff of the army needs some assurance that men are being assigned to divisions to which

they are fitted and given ranks not above their ability. Particularly is this information essential when many recruits are accepted hastily as in the case of the World War. In addition to these demands are those from individuals themselves. Each of us before entering upon some line of endeavor wants to be reasonably certain of success and happiness in its pursuit.

In response to these demands and as an outcome of their own desires to measure significant individual differences, psychologists have expended considerable effort in attempting to measure intelligence, in attempting to predict future performance from present ability. They have met with a notable degree of success.

A. The Binet-Simon Scale and Its Revisions.

Alfred Binet, a French psychologist and physician, early in his career became interested in individual differences in ability. In 1898 he wrote an article with reference to their measurement, describing a number of tests which he considered useful in classifying one person with reference to others. Some of these tests were later used in his famous scale which appeared in 1911. In the interim he tried out, as possible indicators of differences in intelligence, anthropometric measurements—circumference of waist and chest, length of forearm and fingers, relative lengths of trunk and limbs, and particularly head measurements. He also studied handwriting analysis and palmistry to discover whether abilities could be predicted from them, but he abandoned them as useless. In addition to examining these schemes, he was adding to his list of performance tests and published in 1905 a group of tests arranged in a scale of increasing difficulty. By 1908 he had rearranged the tests according to the ages of children capable of performing them. He considered a test which 60 to 90 per cent of normal four-year-old children could pass as a four-year-old test; in a like manner he determined at what year-level to place each test. In 1911, the year of his death, he published a revision of the 1908 scale, and it is this revision which is known as the Binet-Simon scale. Simon was a collaborator in a part of the work.

Goddard, then director of the psychological laboratory at the Vineland Training School for Feeble-minded, adapted the scale to American conditions with as few changes as possible. Since then there have been several American revisions, the one most widely used being the one made by Terman and his associates and known as the Stanford-Binet. Its more extensive use is due to the fact that it was most carefully standardized. By standardization we mean that (1) each test or exercise must be given to a large number of children to determine the year-level at which it should be placed, (2) each test must be more difficult for children of the age for which it was designed than for older children and less difficult for children of the age for which it was designed than for younger children, and (3) each test must be required to correlate highly both with performance on all other tests and with success in school.

The exercises placed at three, six, and nine years in the Stanford-Binet are indicated below. These will serve to give an idea of the nature of the scale.

Year III

1. Point to parts of body—nose, eyes, mouth, hair. (3 of 4 correct to pass.)
2. Name familiar objects—key, penny, knife, watch, pencil. (4 of 5.)
3. Pictures. Name three objects in one of three pictures.
4. Give sex.
5. Give last name.
6. Repeat 6-7 syllables—(a) I have a little dog. (b) The dog runs after the car. (c) In summer the sun is hot. (One without error.)

Year VI

1. Distinguish right and left by indicating right hand, left ear, and right eye without error.
2. Discern the missing part from 3 of 4 sketches of the human body.
3. Count 13 pennies.
4. Comprehension. What is the thing to do:
 - (a) If it is raining when you start to school?
 - (b) If you find that your house is on fire?
 - (c) If you are going some place and miss your car?
5. Distinguish coins—nickel, penny, quarter, dime.

6. Repeat 16-18 syllables.

- (a) We are having a fine time. We found a little mouse in a trap.
- (b) Walter had a fine time on his vacation. He went fishing every day.
- (c) We will go out for a long walk. Please give me my pretty straw hat.

Year IX

1. Give day of week, month, day of month (approximately), and year.
2. Arrange five weights of 3, 6, 9, 12, and 15 grams in order.
3. Make change in hypothetical purchases, supposedly buying a four-cent article and giving a dime, a twelve-cent one and giving 15 cents, a four-cent one and giving a quarter.
4. Repeat four digits backwards. 6-5-2-8; 4-9-7-3; 8-6-2-9. (1 correct.)
5. Put three words into a sentence. Boy-river-ball; work-men-money; desert-rivers-lakes.
6. Give three rhymes for 2 of 3 words—day, mill, spring.

A person's performance is expressed in terms of mental age. When six exercises are given in each year-level, the passing of any one counts as two months except above the ten-year level where each counts as four months, since above this age there are tests for only the even years. For example, if in administering the test it is found that a given child does the six things called for in the five-year level, five of the six exercises in the six-year level, and one of the tests in the seven-year level, he is said to have a mental age (mentality or performance ability) of a six-year-old child (five years plus five times two months plus one times two months). If a child found to have a mental age of six is just six chronologically, he is average; if he is less than six chronologically, he is bright; and if more than six chronologically, he is dull. The extent of his retardation or superiority is found by dividing the mental age by the chronological age, both usually expressed in months. This result multiplied by 100 to avoid decimals is known as the intelligence quotient or I.Q., a calculation suggested by Stern and adopted by Terman. The greater the I.Q. the more advanced or brilliant the individual; the smaller the I.Q. the more retarded or

dull. Table 7 shows the ranges of I.Q.'s corresponding to general designations of the amount of intelligence, and it also gives the percentage of children included in each group.

TABLE 7

DISTRIBUTION OF INTELLIGENCE QUOTIENTS OF 905 PUPILS AND THE DESIGNATIONS OF THE SEVERAL GROUPS
(After Terman)

VALUE OF I.Q.	PERCENTAGE OF PUPILS INCLUDED	DESIGNATION
Below 65	.3	Feeble-minded
66-75	2.3	Borderline
76-85	8.6	Backward
86-95	20.1	Dull
96-105	33.9	Average
106-115	23.1	Bright
116-125	9.0	Very bright
126-135	2.3	Superior
Above 135	.6	Genius or very superior

After testing a number of adults, it was found that on an average they had a performance level of 16, and so in calculating the I.Q. of adults, 16 is used instead of chronological age. Testing in the army revealed that the average performance level of the male population of America corresponds to an age level of 13.8 years on the Stanford-Binet. Some testers are now using 14 in place of 16.

Underlying the Binet scale is the assumption that the capacity for learning is revealed in how much has been learned of things which we all have an approximately equal chance to learn. In recognition of this conception, Binet excluded from his test exercises which obviously depended upon specific training. The question, "What is the capital of Nevada?" would not belong in the scale.

The scale is justified not on theoretical grounds but rather on practical ones. The practical criterion of the validity of the scale is how accurately one can predict performance in daily life from the score made. The Binet type of test meets this re-

quirement successfully. A much better prediction of future performance is possible from the score made on a Binet test than may be made from any other data (except score on a group test) obtained in a comparable length of time. The extensive use of the Binet scale attests to its practical value.

No one would argue that the Binet type of test is an absolutely accurate measure of capacity to learn. We shall never have any perfect measure because the things which it is possible to learn are too diverse and numerous. A person may learn one thing somewhat more readily than another. One who is slow in school may readily learn a trade or the social graces or how to play musical instruments. In our institutions for the feeble-minded a person is occasionally found who is remarkable in some one ability, music, rapid calculation, photography, drawing. Such cases are the exception rather than the rule, and the person who makes a low score on the Binet test and achieves marked success in daily activities is likewise the exception rather than the rule. General success or ability is predicted from the Binet test with a high degree of accuracy, although the test does not predict success in many specific lines of endeavor.

B. Group Tests.

At the same time that Binet was evolving his scale, psychologists in this country under the leadership of Catell and later Thorndike were working on the problem of individual differences. The tests were at first sensory and sensori-motor of the type described by Whipple in *A Manual of Mental and Physical Tests*. Measurement was made of simple reaction time to auditory and visual stimuli, of acuteness in discriminating differences in weight, of speed and accuracy in sorting cards by colors, etc. It was not long before scores on the tests were correlated with judgments of "intellectual acuteness" made by teachers and companions. Particularly were the scores made by normal persons compared with those of the feeble-minded. Soon after this, tests correlating highly with estimates of

intelligence were grouped to form a battery and scored to give an approximate rating of intelligence. The success of these batteries, the decided advantages of group tests rather than individual ones of the Binet type, and the pressing need presented by the army situation at the entrance of the United States into the World War, led to the building of the first extensively used group test, the Army Alpha test.

The Army Alpha test is a battery of eight tests, each containing many items. The eight tests may be designated as follows: (1) following directions, (2) solving arithmetical problems, (3) forming practical judgments, (4) designating synonyms and antonyms, (5) rearranging disarranged sentences, (6) crossing out the number which does not fit in a series, *e.g.* 2 4 8 10 16 32, (7) selecting a word which bears the same relation to one given as two other given ones bear to each other, *e.g.* man—arm; tree—(shrub, *limb*, flower, bark), (8) answering informational questions.

The Army Beta test is one designed for illiterates and foreigners, one not involving language. The examiner demonstrates the procedure to be followed. For example, he solves a maze diagrammed on the blackboard, and then the examinees solve those on their test sheets.

All of the many group tests are modelled more or less closely upon the Army Alpha or Beta. The items have been changed to meet the requirements of the group to be tested; some of the tests have been omitted; new types of tests have been incorporated; but nothing essentially new has been added to the nature of group tests. In building most of these modifications of the army test, the aim has been to secure a battery which will more accurately predict school success. Each item or each type of test is correlated with scholarship as measured by the average of school marks. In revision those items which correlate low are dropped and replaced by others with a higher correlation. Since the tests are designed for this practical purpose, it is becoming common to refer to them no longer as intelligence tests but rather as prognostic tests, *i.e.* tests with a known

predictive value. After all, a test is good or poor according to the predictability it provides, and this is found by determining the extent to which scores on the test correlate with performance in some field of activity. No one test predicts performance in all fields. Industrial tests have been devised for selecting employees, and in many ways it would be as logical to call these intelligence tests as to call the scholastic scales intelligence tests. *Each test, whatever its nature, is to be regarded not as a test of intelligence but as a predictive instrument for determining capacity for definite tasks.*

THE RESULTS OF INTELLIGENCE TESTING

A. In Dealing with the Feeble-Minded.

Binet employed his tests primarily for detecting feeble-mindedness, and when they were introduced into this country, they were at first used mainly for this purpose and for classifying persons already in institutions for the sub-normal. It is advantageous to group the inmates of an institution on the basis of their performance level, since their training and care can then be directed more effectively. Previous to the advent of intelligence tests, the feeble-minded were commonly classified according to structural type—cretin, micro-cephalic (small-headed), macro-cephalic, mongol, etc. But a member of any one of these groups may be highly deficient or approach normality. As a result of the new measures indicating relative standing in ability, the feeble-minded were divided into three groups, idiots, imbeciles, and morons. The terms idiot and imbecile had been used previously but with varied meanings, and Goddard introduced the word moron. By arbitrary agreement idiots are defined as adults having mental ages up to 2 years, imbeciles as having mental ages from 3 to 7, and morons as those having mental ages from 8 to 10, 11, or 12. The upper limit has not been agreed upon. The I.Q. ranges for the three grades are commonly given as follows: idiots from 0 to 24, imbeciles from 25 to 49, and morons from 50 to 65, 70, or 75.

The lack of agreement for the upper limit is due to the fact

that feeble-mindedness is primarily a sociological or legal concept. Obviously some people are legally and socially incompetent and need special care. An individual with a mental age of ten as determined by the Binet tests may be socially competent because of the nature of the tasks for which he has been trained from infancy or because of personality factors. Another with a mental age of twelve may be incompetent before the law. Consequently the latter would be committed to an institution for the feeble-minded while the former would not.

As testing branched out and results were obtained from normal children, the whole concept of feeble-mindedness underwent a change. Prior to the employment of tests, the feeble-minded were regarded as a sort of separate species, as a group distinct from normal people. It was soon discovered, however, that scores on intelligence tests are distributed in the form of a bell-shaped curve, that feeble-mindedness is a quantitative difference with only an arbitrary dividing line between it and normality.

B. In Schools.

Before group tests were devised, only children who did very poor work were tested. Many of them were found to be very low in intelligence, but others were discovered who had average or even high intelligence. The finding of high general ability in poor students spurred those in charge to the attempt to find other causes for poor work. Sensory defects, language handicaps, poor health, emotional and social maladjustment were in consequence given greater attention than they had previously received, and as an inevitable outcome mass education gave way to some extent to individual education.

The advent of group tests made it possible to secure intelligence ratings for all students. It requires as an average an hour to give a Binet test to a single child, and the test must be administered by one trained for the task. Group tests may be given to a group of any size, and most of them may be administered without special training of the examiner. Many grade

schools now place their pupils in sections on the basis of scores made. Other systems are planned so that the bright student completes the grades in six years without omitting any grade; the average student completes them in eight years; and the dull student in ten years without repeating any grades. Still other systems adopt the scheme of keeping all levels of intelligence in the same section but varying the kind and amount of work required to conform to individual intelligence. In many high schools sectioning is practiced, and in some the student is advised as to his courses on the basis of his intelligence record. For example, students with low intelligence ratings are advised against taking a college preparatory course. In colleges three chief uses have been made of the tests. (1) They are used by many privately owned or endowed institutions as supplements to or in lieu of entrance examinations. (2) In a great number of colleges and universities they are used as aids in sectioning or in determining the kind and amount of work to be assigned to a student. (3) In all which employ them they are used in various administrative ways, in determining whether a student should be allowed to take extra work or honor courses, should be kept on probation or dropped, etc.

A development which is closely related to, if not a result of, intelligence testing is the formation of special classes for exceptionally dull children. They not only learn more slowly, but they require a different kind of teaching than that employed in the ordinary classroom. A still more interesting result is the formation of special classes for the exceptionally bright. Of course, it has always been recognized that some students are brighter than others, but the results of intelligence testing revealed that for each child who is markedly below average there is one equally far above average. This led to the reasoning that, if the dull ones require a different kind of teaching from that of the ordinary classroom, the bright ones also need special instruction. If public funds were to be expended in forming special classes for the retarded, they might be spent as profitably in providing special instruction for the very bright. Almost

everyone is familiar with a case in which the very bright child is extremely bored by the regular school work. He forms bad habits, becomes indolent, supercilious, mischievous, even anti-social. Yet he is the one in whom society should be building desirable habits, for he is the probable leader of the next generation.

In addition to these direct results of the employment of intelligence tests are several indirect influences. Educators early saw the advantage of standardized tests, *i.e.* those known to be highly differentiating, capable of objective scoring, and for which norms have been established. As a result, they set about building subject tests—handwriting tests, arithmetic tests, reading comprehension tests, reading speed tests, etc.¹ These tests have proved valuable, but a discussion of them is outside the province of this book. The development of intelligence tests also resulted indirectly in the introduction of objective quizzes and examinations of which four types are in common use, (1) the true-false, (2) the multiple choice, (3) the one-word completion types, and (4) the type in which the unassociated word in a group of associated words is checked.

Although intelligence tests are useful, their worth has been exaggerated by many educators. The best group tests have a coefficient of correlation with scholarship of only .50 to .60. These values are often considered high correlations, but in reality they allow only very inaccurate prediction of individual performance. If the name of a student in a given school is selected at random, the chances of his being above average in scholarship are 50 out of 100 and of his being below average are 50 out of 100. If the name of a student is selected at random from the group which has made a score above average on an intelligence test with a correlation of .50, the chances of his being above average in scholarship are 57 out of 100 and of his being below average are 43 out of 100. In other words, 43 per cent of the students are misplaced when they are divided into

¹ See Monroe, DeVoss, and Kelly, *Educational Tests and Measurements*, Houghton Mifflin Co., 1924, for a description of such tests.

two groups on the basis of intelligence records. If the attempt is made to group students into three or four sections instead of two on the basis of intelligence scores, the percentage of misplaced students is greater. Figure 45 shows what per cent of a

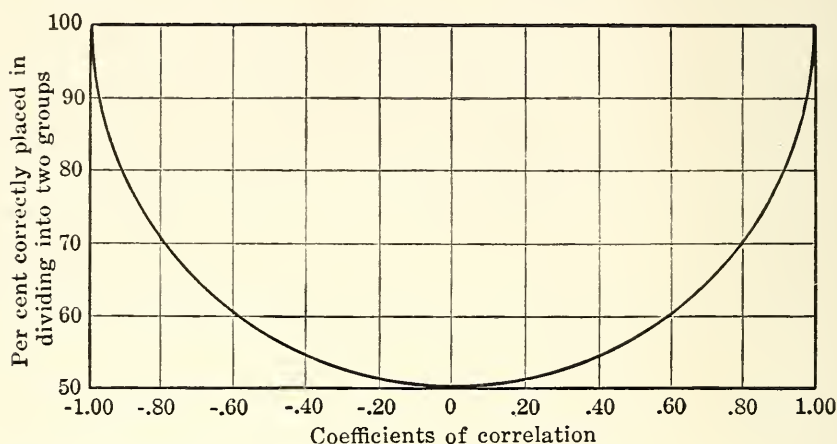


FIG. 45.—Showing the degree of correctness of predictions that an individual's ability in one task will be above or below average when the predictions are made on the basis of ability in another task which has a known correlation with the first task.

group which is above average in one performance or test will be above average in another when the coefficient of correlation between the two performances or tests is any one of the values from -1 to 1 .

C. In Relation to Social Problems—Delinquency, Crime, Dependence, and Unemployment.

Studies made soon after the introduction of the Binet tests into this country indicated that a high percentage of delinquents were feeble-minded. In four studies made in 1911, 1912, and 1913 by Hill and Goddard, Gifford and Goddard, Bridgman, and Otis the average of the estimations was 81 per cent. Correction of faults in the earlier tests and more extensive studies have resulted in a reversal of this earlier conclusion. It is now agreed that there is little if any difference in the intelligence of either young or adult delinquents and that of the population at

large. Healy² from a study of 1212 cases in 1922 gives the percentage of feeble-mindedness among delinquents as 7. Doll³ gave the Army Alpha to 839 prisoners in the New Jersey State Prison and found that their average score differed only slightly from that made by white draft recruits. Anderson,⁴ in surveying the Connecticut Industrial School for Girls, found the distribution of scores given in Column 4 of Table 8, and investigators⁵ in the army found the distribution given in Column 5 for Leavenworth prisoners and that given in Column 6 for guardhouse prisoners. The fact that a large percentage of guardhouse prisoners were of low intelligence is perhaps explained by their inability to learn the army rules quickly. In consequence, many men of low intelligence committed infractions through ignorance. The many studies lead to the conclusion that, although delinquents are on the whole slightly lower in intelligence, the difference between them and the population at large is not great. Consequently, feeble-mindedness is by no means the major cause of crime and juvenile offenses.

TABLE 8

COMPARISON IN PERCENTAGES OF THREE DELINQUENT GROUPS WITH DRAFTED MEN ON THE BASIS OF SCORES ON THE ARMY ALPHA TEST

RATING CLASSIFICATION		DRAFTED MEN	DELINQUENT GIRLS	LEAVEN- WORTH PRISONERS	GUARDHOUSE PRISONERS
A	Very superior	4.1	0.5	5.8	2.1
B	Superior	8.0	3.0	8.8	3.4
C+	High average	15.2	14.7	16.0	8.3
C	Average	25.0	25.4	23.8	18.6
C-	Low average	23.8	26.9	20.8	21.9
D	Inferior	17.0	17.3	18.8	25.5
D-	Very inferior	7.1	12.2	6.0	20.6

² Healy, W. "The Practical Value of Scientific Study of Juvenile Delinquents," *Publication 96. Children's Bureau, U. S. Dept. of Labor.*

³ Doll, E. A. *Psychologists' Report, N. J. State Prison.*

⁴ Anderson, J. E. "A Mental Survey of the Connecticut Industrial School for Girls," *Journal of Del.*, 7, 271-282.

⁵ "Memoirs," *National Academy of Science*, Vol. XV, Part III, Chap. 12.

It is, however, an advantage to have an intelligence rating of delinquents, particularly of juvenile offenders. It is recognized that our juvenile courts and penal institutions must, if possible, re-educate the persons coming under their jurisdiction and turn them back as useful citizens. If this is to be accomplished, a close study of each offender is necessary. Authorities feel that attention has too long been given to the offense rather than to the offender, and as a result we find psychologists attached to many of our juvenile courts and on the staffs of many prisons.

The present indications are that dependents and unemployed are for the most part of low intelligence. Several studies indicate that approximately 15 per cent of dependents are feeble-minded and 40 to 50 per cent markedly retarded. With respect to the unemployed, few studies have been made. Pintner and Toops⁶ found the following percentage distributions for ninety-four cases in one city and forty in another.

	<i>City A</i>	<i>City B</i>
Feeble-minded	28.7	7.5
Borderline	29.8	25.0
Backward	28.7	32.5
Normal	8.5	20.0
Bright	4.3	15.0

The term feeble-minded is obviously used in this study to designate the lowest group of an arbitrary score division. It is doubtful whether the cases tested may be considered representative of the unemployed because of the small number of cases studied and because the higher grade of unemployed would be less readily available as subjects.

D. In Industry.

There are rather significant differences in the average intelligence scores of the men employed in the various vocations as shown by data collected in the army. (See Figure 46.) Yet Binet and school tests are of little value to employment and personnel managers, for there is only a slight correlation between

⁶ "Mental Tests of Unemployed Men," *Jour. of Appl. Psychol.*, 1, 325-341, and 2, 15-25.

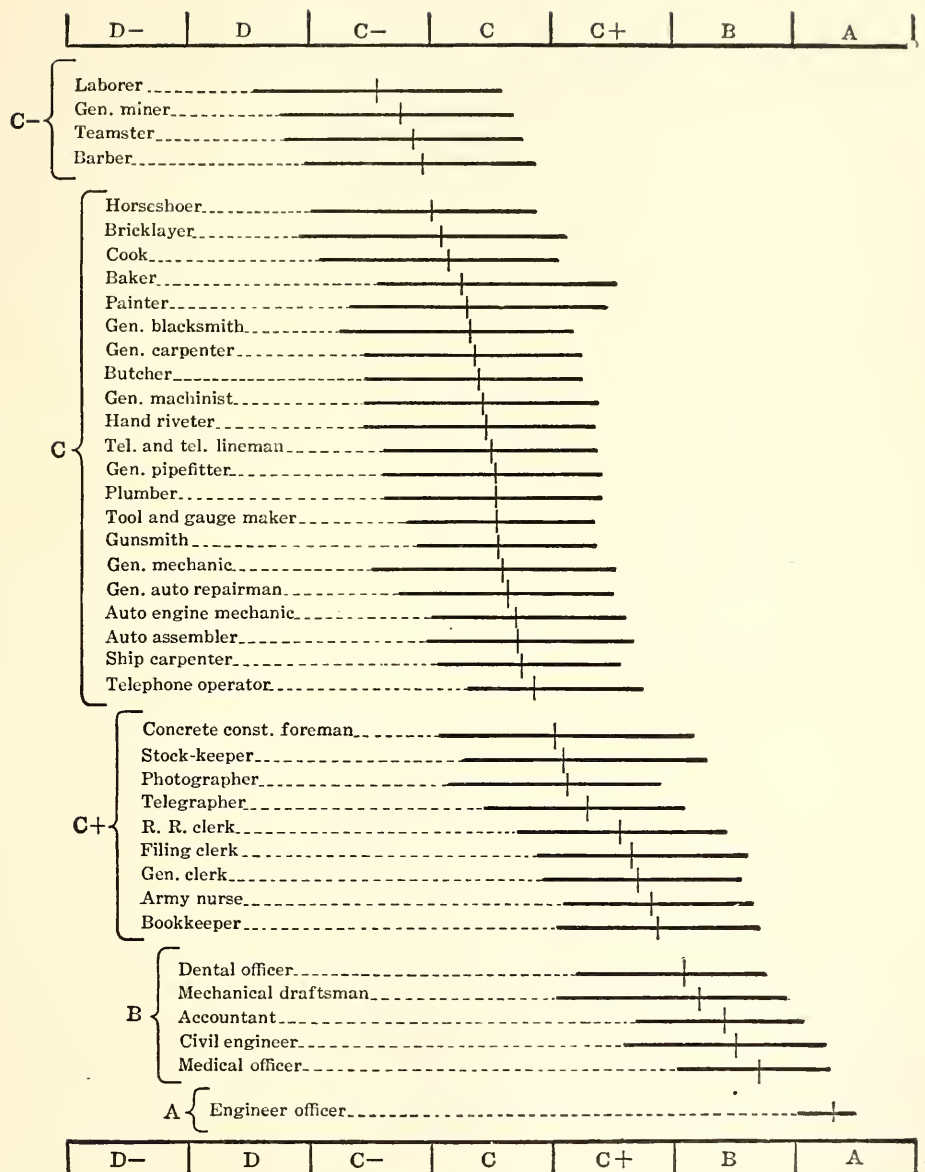


FIG. 46.—Occupational intelligence standards. Based on data for 18,423 men. Data taken from soldiers' qualification cards. Length of bar shows range of middle fifty per cent. Vertical crossbar shows position of median. (From Yoakum and Yerkes.)

intelligence records and success in a given vocation. If a person has a degree of intelligence above the minimum requirement for his vocation, his success is determined by specific abilities. In fact, too much intelligence may be a handicap in some occupations, for the bright individual may find his work boring.

It is rather in the development of trade tests (mainly vocational information tests) and special industrial tests designed to correlate highly with success in a given occupation that intelligence testing has made its contribution to industry. The reader is referred to such books as Chapman, J. C., *Trade Tests*; Hollingworth, H. L., *Vocational Psychology*; Link, H. C., *Employment Psychology*; and Burt, H. E., *Principles of Employment Psychology* for information with reference to the nature of trade and vocational tests, and their uses.

E. Race Differences.

The only extensive data with reference to race differences in intelligence are those comparing the negro and the white. Table 9 shows the percentage distributions of scores as found in the army. Several other studies comparing scholarship or scores on group intelligence tests show approximately the same amount of difference. On the other hand, when whites and negroes of approximately equal social and economic status are selected, only a slight difference between the two groups is revealed.

TABLE 9

COMPARISON OF THE ARMY ALPHA SCORES OF NEGROES AND WHITES

GROUP	SCORE IN LETTER GRADES		
	D, D-	C-, C, C+	A, B
Whites of five northern camps	19.4%	67.6%	13.1%
Negroes " " "	45.3	51.1	3.6
Whites of five southern camps	34.8	56.8	8.6
Negroes " " "	78.7	20.6	.7

Further data collected in the army with reference to the abilities of the foreign-born agree with the common judgment as to the relative standing of immigrants from the various coun-

tries. The per cent of men of foreign birth falling in the two high classes and the two low ones on the Alpha rating is shown in Table 10. The immigrant is, of course, not necessarily a true sample of the population of his country.

TABLE 10

PERCENTAGES OF FOREIGN-BORN DRAFTED MEN RATED AS A OR B AND AS D, D-, OR E ON THE ARMY TESTS
(From Pintner)

COUNTRY	A AND B	D, D-, AND E
England	19.7	8.7
Scotland	13.0	13.6
White draft	12.1	24.1
Holland	10.7	9.2
Canada	10.5	19.5
Germany	8.3	15.0
Denmark	5.4	13.4
Sweden	4.3	19.4
Norway	4.1	25.6
Ireland	4.1	39.4
All foreign countries	4.0	45.6
Turkey	3.4	42.0
Austria	3.4	37.5
Russia	2.7	60.4
Greece	2.1	43.6
Italy	0.8	63.4
Belgium	0.8	24.0
Poland	0.5	69.9

F. Sex Differences.

Various comparisons of the intelligence of the two sexes show that there are probably no fundamental differences. Whatever differences in ability exist are apparently due to the type of training given each sex and to structural differences such as muscular strength. On the basis of average score on the Binet type of test, American girls are slightly above boys. The extent of this difference is indicated in Figure 47. It will be noted that in early youth the difference disappears. When the results of the many comparisons of college men and college women are combined, no difference is found. There are more

male than female inmates of feeble-minded institutions, but this is in part due to the greater readiness with which males are committed. There are more eminent men than women, but there are many economic and social factors favoring this difference.

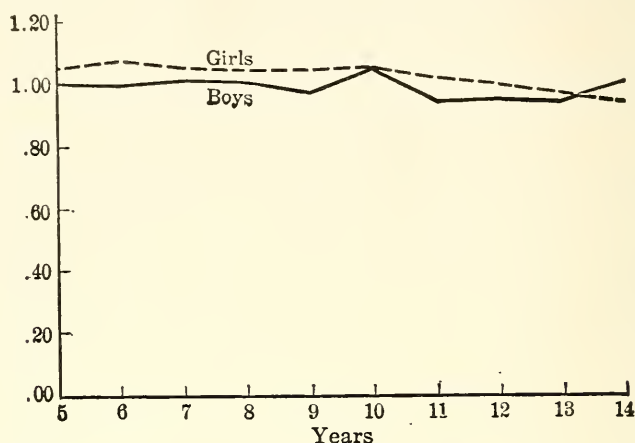


FIG. 47.—Comparison of average performance of boys and girls on the Stanford-Binet tests. (After Terman.)

THE FUTURE OF TESTING

The Binet type of test has reached its culmination in the Stanford revision. Little if any more improvement may be expected in it. Group tests of the Army Alpha type have been improved to a point where no higher correlations with scholastic ability are obtainable. Industrial tests are still being improved, and at present a great deal of effort is being expended in devising tests which, it is hoped, will measure personality and character traits, but many obstacles are encountered. Just what the future holds is impossible to predict, but mathematics lays down two principles which point the direction to be taken. One test must have a low correlation with other tests if it is to supplement rather than duplicate them, and each test must correlate highly with performance in some daily activity or it is useless. The future may develop a battery of such tests, each correlating low with every other and each correlating highly with ability in at least one line of endeavor. When a battery

of this type is developed, vocational and educational guidance and selection can be scientifically conducted. It may well happen that the present intelligence tests will have to be discarded before this advance takes place, for it seems almost impossible to build a test which has a low correlation with them.

FAMILY RESEMBLANCES IN INTELLIGENCE

We have already pointed out in the previous chapter that the intelligence of near relatives is somewhat highly correlated. When a study is made of extremely bright families or of very dull families, this correlation stands out more strikingly. Galton, the founder of the eugenics movement, selected 977 eminent men and found that of these 332 had eminent fathers, brothers, or sons and 203 eminent grandfathers, grandsons, uncles, or nephews. He estimated that 977 average men would probably have 4 eminent relatives.⁷ Dugdale⁸ studied what he called the Jukes family with reference to pauperism, crime, and prostitution, and found an appalling record. Goddard made a study of the forebears of one of the inmates of the Vineland Training School. He traced them back to a Revolutionary soldier who just before the war became the father of an illegitimate child. This soldier upon returning from the war married a girl of his own social status. Descended from him there were, then, two lines. Of the 480 known descendants of the illegitimate mating 143 were classed by Goddard as feeble-minded, 33 were sexually immoral, 36 were of illegitimate birth, and 24 were confirmed alcoholics. Nearly all were of relatively low mentality. The descendants of the other mating were of high intelligence and included numerous lawyers, statesmen, wealthy landholders, and physicians.⁹ Similar to Goddard's finding with reference to the normal line of the Kallikak family are the results of the study of the Edwards family. Of the 1394 identified descendants of Jonathan Edwards, 13 were college presidents, 65 college professors, 60

⁷ Galton, F. *Hereditary Genius*.

⁸ Dugdale, R. L. *The Jukes*.

⁹ Goddard, H. H. *The Kallikak Family*.

physicians, 100 clergymen, 75 army or navy officers, 69 prominent authors, 100 lawyers, 30 judges, 80 prominent public officials, and a great many other successful and useful citizens. Several other studies of exceptional families or of the relatives of exceptional individuals have been made and indicate that the bright and the dull belong in general to families which are bright or dull.

CONSTANCY OF RELATIVE STANDING IN INTELLIGENCE

A person retains within close limits his relative standing throughout life except of course in cases of injuries and debilitating sicknesses. Many simple tests which can be administered to infants less than six months old enable the psychologist to predict with a fairly high degree of accuracy the I.Q. which the child will have when later tested with a Binet test. Many children have been given Binet tests three or four times in the course of their childhood. Slight variations in the values of the I.Q.'s for each child are found and occasionally a marked variation. But for the most part, the I.Q. remains constant,

TABLE 11

CORRELATIONS OF THE SCHOOL MARKS OF ONE YEAR WITH THOSE OF OTHER YEARS

As determined by Kelley:

First year of high school and seventh grade	.72
“ “ “ “ “ “ sixth grade	.73
“ “ “ “ “ “ fifth grade	.53
“ “ “ “ “ “ fourth grade	.62

As determined by Smith:

H. S. average and univ. freshman average	.48
“ “ “ “ sophomore average	.39
“ “ “ “ junior average	.47
“ “ “ “ senior average	.28
First and second year high school	.77
“ “ third year high school	.67
“ “ fourth year high school	.66
Univ. freshman and sophomore years	.73
“ “ and junior years	.61
“ “ and senior years	.45

just as a person's relative height remains constant. Many present college students were given Binet tests when children and almost without exception the I.Q.'s were high. Further, a student's relative standing remains about the same through high school and college. The correlations given in Table 11 show this tendency to maintain a definite level in school work. In addition a student's standing in school is a fairly reliable index of his after-school status. This holds true whether post-school success is measured in terms of salary, of distinctions such as inclusion in *Who's Who*, or of ratings by colleagues. (See Tables 12 and 13.) The person's adult standing can be predicted approximately as accurately from infant ability as can adult height be predicted from length at birth.

TABLE 12

SHOWING THE RELATION BETWEEN SCHOOL QUARTILE AND SALARY OF GRADUATES OF PRATT INSTITUTE

CLASS AND YEAR	CASES	AVERAGE SALARIES OF THE			
		1ST QUARTILE	2ND QUARTILE	3RD QUARTILE	4TH QUARTILE
Mechanical '07	35	\$1,800	\$1,675	\$1,362	\$1,387
Mechanical '08	41	1,450	1,512	1,512	1,275
Mechanical '09	39	1,375	1,262	1,313	1,137
Electrical '07	26	1,750	1,675	1,675	1,412
Electrical '08	36	2,147	1,437	1,262	1,262
Electrical '09	41	1,462	1,212	1,387	1,200
Averages		1,664	1,462	1,418	1,279
Percentages		100%	87%	85%	76%

TABLE 13

SHOWING THE RELATION BETWEEN COLLEGE HONORS AND INCLUSION IN *Who's Who* FOR THE 1667 GRADUATES OF WESLEYAN UNIVERSITY FROM 1833-1899

	PER CENT WITH DISTINCTION ENTITLING TO INCLUSION IN <i>Who's Who</i>
Honor Men—(140)	50
P. B. K. Men—(461)	31
Remainder—(1206)	9

Since a person tends to keep his relative position from birth, it may be said that his intelligence is largely determined by inheritance and embryonic environment. That post-birth environment plays its rôle is shown in the fact that the relative standing is not absolutely maintained.

CONCLUSIONS

The concept of intelligence has more theoretical than practical value, because the practical interest lies not so much in general capacity for learning as in abilities in definable tasks—ability to earn a living, to do school work, to succeed in a definite vocation.

Those tests which have been termed intelligence tests predict with a fair degree of accuracy the level of general adjustment which will be achieved. They predict school success more accurately than success in any other field. Other tests have been devised to predict ability in specific vocations and still others to measure achievement in school subjects.

Infants are more likely to succeed if they are members of families whose level of achievement is high and less likely to succeed when born of families whose level of adjustment is low. A child's probable achievement can, however, be more accurately predicted from his early accomplishments than from the achievements of his parents.

QUESTIONS AND EXERCISES

1. Account for the widespread belief that the exceptionally bright child will be a failure.
2. Are there occupations in which exceptional brilliance is disadvantageous?
3. Does our educational system favor any particular level of intelligence?
4. What are the differences between the problems of vocational selection and those of vocational guidance?
5. Discuss the assumption underlying the Binet tests, that the capacity for learning is revealed in how much has been learned of things which we all have an approximately equal chance to learn.
6. If a new test whose content is different from the present intelligence tests is devised and found to correlate highly with scholarship, why would it

not necessarily make possible a more accurate prediction of scholarship?

7. If a person were interested in adopting a six-months-old baby, should he be influenced more by the history of the child's family or by the behavior development attained by the child?

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CHAPTER 19

PERSONALITY

Since the beginning of literary activity, a favorite theme has been the portrayal of characters or personalities. In practically all literary efforts men are conceived as belonging to types—the fool, the scoffer, the wise man, the flatterer, the deceiver, the scoundrel, the intriguer. The novelist often shows exceptionally keen insight into human nature, an insight which at times excites the envy of the psychologist. But the novelist usually makes his characters fit into his plot. In consequence, he has a tendency to emphasize the traits which further the plot and to disregard those which are not demanded in its development. His characters become to some extent caricatures or idealizations of persons in real life. The psychologist in his study of personality must avoid these tendencies. He has the problem of depicting personality as a whole, not of picturing specific traits, the task of finding the nature of personality in general, not the personality of one individual, and the problem of analyzing personality into its components, not of synthesizing the components into personalities. Further, the psychologist must study more deeply into the causes of personality traits than does the novelist.

THE NATURE OF PERSONALITY

Popularly personality is considered an intangible something in an individual which leads others to form a favorable or unfavorable attitude toward him. When he makes a favorable impression upon us, we say that he has a pleasing personality; when he creates an unfavorable attitude, we speak of his poor personality; when he makes no definite impression, we call his personality weak. Popularly personality is considered as being

only slightly correlated with intelligence, for a brilliant person often possesses a poor personality, and many less brilliant people have pleasing personalities. Personality, however, remains intangible and undefined in popular thinking.

When careful attention is given to the nature of personality, it remains intangible just as the strength of a bank is intangible, but personality is definable just as is the strength of a bank. The latter is defined as the balance between concrete assets and liabilities, and when this balance is found, the strength of the bank is known. Each person has assets and liabilities on the personality side. He has ways of conducting himself which are socially approved; these are his assets. He also has ways of acting which are socially disapproved; these are his liabilities. Personality may, then, be defined as the balance between socially approved and disapproved traits.¹ The greater the proportion of assets the higher is the level of personality, just as the higher the proportion of assets the greater is the strength of a bank.

The manner in which traits are abstracted from concrete situations was illustrated in Chapter 13. Perseverance is a trait of action abstracted from many concrete acts in which persistence is exhibited. Any other characteristic—poise, cheerfulness, honesty, open-mindedness, vivacity, courage—is in like manner an abstraction from observations of concrete acts. The trait has no actual existence within the person. The actions do not express the trait but rather *are* the trait. From this it follows that a person may be persevering in one situation and not in another and may be honest under one set of circumstances and not under another. When we say that a person is persevering or has the trait of perseverance, we mean that in a majority of situations his actions are characterized by perseverance. Personality is a composite of these traits, and, like them, it has no real existence. It is not expressed in action but it is ways of acting when they are balanced for social desirability and undesirability.

¹ Cf. with the definition given by Watson.

PERSONALITY OR TRAIT TESTS

Within the past few years psychologists have spent much effort in devising what have been labelled personality or trait tests, as *e.g.* honesty tests, intraversion-extroversion tests. This test movement, in spite of the warnings of some of the leaders, has not escaped the fallacy involved in assuming that a test tests what its name signifies. As pointed out in the preceding chapter, "intelligence tests" are no longer regarded as tests of intelligence but rather as instruments for predicting performances of definite sorts. The essential requirement of a test is that the attribute to be tested must be measurable independently of the measure used to test it. We can test the length of a wire by determining its weight only because various lengths and their weights have been measured and the relationship between the two measures determined. We can test a pupil's ability to make school grades only because various test scores have been obtained and related by statistical correlation to the school marks received. An honesty test becomes an honesty test not when it is given that name but when it is found that the score made on the test has a definite relation with some measure of honesty. There are almost insuperable difficulties in the way of measuring honesty. The chief of these has already been mentioned: honesty as such does not exist. Furthermore, even concrete acts are not honest except in relation to the situations in which they are performed. The only measure of honesty is the judgment of people intimately acquainted with the individual, people whose decision is determined by somewhat varying standards and from whom both honest and dishonest acts are intentionally or unintentionally concealed.

If the devised tests are evaluated on the basis of their correspondence with the judgments of intimate acquaintances, their value seems to be slight. The correlations range for the most part from .20-.50, and from Figure 45 it is readily seen that these coefficients have very little predictive or test value. Furthermore, it is found that if the scores made on a test which

is called an honesty test are correlated with the judgments made for some other trait, the coefficients of correlation are almost as high in many cases as when the correlation is with judgments of honesty. This may mean that the test tests other things in addition to honesty or that the judges make their estimates on the basis of other attributes than honesty. Just what will become of the personality testing program cannot be predicted, but it is interesting as a shift by psychologists to problems of high practical import. The leaders are aware of the difficulties and recognize that the present achievements have not solved the problems, but the only way to surmount these difficulties is through continued effort toward means of accurate measurement.

THE DEVELOPMENT OF PERSONALITY TRAITS

If personality analyzes into traits of action, and if traits analyze into features of definite acts, then the development of personality resolves into the acquisition of *socially important* habits. Honesty is not instilled by teaching the child to verbalize, "Honesty is the best policy," but rather by teaching him to return the extra change when a mistake has been made in his favor, to assume rather than to shift responsibility when he has broken a window, to represent fairly the goods which he trades with his playmates. In conjunction with this concrete training, he must be taught to generalize, for it is through this abstract training that he comes to ask himself whether he is acting honestly. As a consequence of asking himself this question, he comes to act honestly in situations other than those in which he has had specific training in being honest.

Since personality development is a matter of the acquisition of habits, and since we have already devoted considerable space to the basic principles of learning, it remains only to point out some of the broader principles of personality development.

A. The Influence of the Home.

That the roots of personality are laid in the home in the first few years of a child's life has long been recognized in a common-

sense way. Without outside contacts the child may be spoiled through pampering. He may learn disobedience from nagging, from being continuously told "Don't" unaccompanied by reason and enforcement. He may develop several schemes for enforcing his demands, the nature of the scheme depending upon which one he has in his trial and error reactions found effective with his parents. He may learn dependence or independence, timidity or aggressiveness, determined by whether the parents continuously interfere and thwart or co-operate and act understandingly.

It is interesting to note that a large per cent of juvenile delinquents come from homes of two sorts, one in which they are scolded and punished for almost everything they do and the other in which they are practically never scolded or punished. In either case the child has no opportunity to learn the distinction between right and wrong, to learn what may be done and what is not to be done.

Our universities are rapidly establishing bureaus or institutes for child study. Two investigations conducted under the direction of J. E. Anderson at the University of Minnesota are interesting and instructive with reference to the influence of the home. In one study each child of the nursery school group is placed in a room with each of the other children and a toy. They are observed through a peep-hole with reference to the schemes adopted for securing their wishes. The various schemes are commanding, pleading, exhorting, whimpering, begging, suggesting, cajoling, and bargaining, but the interesting thing is that some children utilize only one scheme, no matter who their playmate is and irrespective of how unsuccessful they may be, while others vary their schemes according to the characteristics of the playmate and try one after another in case of failure to win their point. It can scarcely be doubted that the nature of the attempt to make simple social adjustments with playmates is determined by home conditions. The other investigation is merely a matter of singling out one child after another and observing his behavior

in spontaneous play. It is found that some children take the lead as much as 95 per cent of the time, while others assume the rôle of leader only 5 per cent of the time. Whatever the causes of this difference, its significance is clear. One child is receiving nineteen times as much practice in leading as another. As Anderson remarks, "Life is something like a game of billiards in which the better player gets more opportunity for practice and the poorer player less."²

On the basis of his observations and study, Thom³ lays down the following set of guides for parents:

"Don't be over-solicitous. Children may become self-centered and develop imaginary complaints simply because illness is looked for.

"Don't baby your children too much. The child who is closely tied to his mother's apron strings is deprived of the chance of learning how to live with his neighbors.

"Don't try to give your children everything they happen to demand. Very early in life the child must learn that things cannot be had simply because he desires them.

"Don't bribe. So often we hear, 'Now Johnny, be a good boy and mother will give you a penny.' Soon Johnny will no longer be satisfied with one penny and must have two or three.

"Don't cheat. Frequently parents will misrepresent or lie to keep a child quiet or gain a desired result. Suddenly they waken to the fact that their child has no regard for the truth and they wonder why.

"Don't make meaningless threats. 'Be good or the doctor will cut your tongue out,' or 'Be quiet or I'll whip you,' may do one of two things: control the child through terror, which is disastrous, or breed contempt for parents whose threats are never fulfilled.

"Don't talk about or laugh at children in their presence. Self-consciousness is harmful and quickly developed.

"Don't be cold and repelling. A parent who is too busy to bother with a little child's nonsense will never be bothered by his real problems.

² J. E. Anderson. "Genesis of Social Reactions in the Young Child," in *The Unconscious, A Symposium*.

³ Thom, D. A. "Child Management," *Children's Bureau Publication No. 143*. U. S. Dept. of Labor.

"Don't be discourteous. Children have their own plans, which are frequently utterly disregarded by adults. If you must interfere, show consideration.

"Don't disagree over discipline before the child. Settle differences in private."

B. The Influence of Playmates.

1. *Childhood traits which incur animosity.* Boys of the sand-lot age hate a sissy. They do not understand that the boy is not to be blamed, that his parents have caused his peculiarities, that his mother persists in treating him like an infant, bathing him, tucking him into bed, cutting his meat for him, and otherwise refusing to allow him to grow up. They merely recognize that he is different from them, hold him responsible, and label him "Mamma's baby."

The child who is awkward or frail is blamed by his playmates. The boy who cannot play his position on the sand-lot ball team or take part in other games in which boys engage is derided and bullied. If he were crippled, they would make concessions, but when he is merely frail or awkward, they recognize only his difference from them and blame him for it. Young girls make fun of an ungainly companion, especially if the clumsiness is accompanied by peculiarities of dress.

Children dislike a playmate who is marked by peculiarities of interest. It may be that the child is precocious; the performance level may be twelve when the actual age is nine. This child does and wants to do the things that twelve-year-olds do, and he cannot get along with children of his own age. Neither will he be welcomed by twelve-year-old groups, for they do not wish to be bothered with so small a playmate.

Again the child may be snubbed, because through isolation he has failed to learn the games of childhood. His associates cannot understand how anyone could have lived so long and have remained so ignorant.

Perhaps selfishness is despised as sincerely as any trait. The child who has not learned in the home that he cannot always have his way, who has been spoiled and pampered, who has not

learned to share his playthings with occasional visitors, meets with disaster when he ventures into a group unaccompanied by adults. Nothing remains for him to do but to cry or to run home and complain to his parents. The nicknames of "Cry-baby" and "Tattler" are as odious as any that children are capable of applying. If he receives the sympathy of his parents, matters are made the worse.

In the above cases we, as adults, can see that the child himself is scarcely to be blamed, but children fail to understand any trait that sets a playmate off as different from them. The unusual child, no matter what the nature of his distinguishing characteristics, encounters a hostility from the group. Supervised play is consequently advantageous from two angles: the child is helped in the removal of his characteristic, and the other children are helped in understanding it and in taking a more tolerant attitude toward its possessor. To engage successfully in childhood games and play is to begin the development of those social habits which are demanded for the development of a pleasing personality; it is to learn lessons of give-and-take which are essential to a healthy attitude toward others as well as to the winning of approval from others.

2. *Traits originating from group hostility.* Once the hostility has been aroused, several avenues of action are open, and the one taken depends upon variant circumstances. The resulting action may be such as (a) to remove the trait, (b) to remove the hostility without eliminating the trait, or (c) to remove the discomfort caused by the hostility.

a. DEVELOPMENTS THAT REMOVE THE TRAIT. (1) Actual Removal of Trait.—The child who finds himself unsuccessful in group play may have the cause of his failure pointed out to him and with the help of his parents, playground supervisor, or some other interested person set about to remove the objectionable characteristic. If he is somewhat older and has been taught to overcome his difficulties, he will on his own initiative set about this task. Demosthenes is the classical example. Having been ridiculed for his speech defect, he took steps to

overcome it, going to the extreme of practicing with pebbles in his mouth. Roosevelt is another example. He was frail and in consequence reticent. Learning his weakness, he became vigorous, energetic, aggressive, a man deserving of his place as the hero of American youth. In many cases the weakness is transformed into a greatly admired trait. Demosthenes did not stop when he became able to speak moderately well but continued until he became known as one of the greatest of orators. Roosevelt was not satisfied to attain average health.

(2) Pretended Removal of Trait.—Sometimes in this over-compensation, the development itself becomes objectionable, because of an incorrect analysis of the reason for the unpopularity. The college student who finds himself unpopular may decide that his lack of favor is due to the fact that he does not talk enough, resolves to contribute his share to the conversation, becomes loquacious and probably a bore. Or he may decide that he is too sober and so decides to laugh more readily and more heartily. He most probably becomes boisterous and his sense of humor is considered perverted. The man who finds himself an outcast because of his sins is too likely to become a “goody-goody” in his reform.

b. DEVELOPMENTS THAT REMOVE THE HOSTILITY. (1) Avoidance.—The simplest way to avoid animosity is to avoid the group. It may be that hostility is encountered in only certain types of situations, and consequently the individual need take care to avoid only these. The avoidance habits will be the scheme adopted if the child is not forced to enter group activities and certainly is the one to be expected when the parents offer sympathy.

(2) Phantasy.—When group activities are avoided, the child may engage in individualistic ones. He may read a great deal. Since many of the books for children, especially for boys, are stories of the poor and neglected child who has become successful, he may readily imagine the stories to be real and himself the hero. He retreats not only from the group but from all reality and lives in a verbal world where rebuffs and dis-

couragements are unknown, or, if known, where they are readily overcome by his imagined resourcefulness. A shut-in or introverted personality is developed, and in extreme cases, insanity of the dementia praecox type is the ultimate result.

(3) Special Abilities.—It may be that instead of engaging in activities which stimulate the imagination, the child engages in constructive play, making his own radio set, electrical devices, or products from his chemical kit. He may become so markedly proficient in his chosen line that he regains the esteem of his playmates. Of course, esteem will be recovered only if the accomplishment is one that appeals to his companions as worth while. The results when his accomplishment fails to win favor will be discussed presently.

(4) Pseudo-Explanations.—Another manner in which hostility may be reduced is to offer an explanation for the trait. This may change the attitude of the group from one of censure to one of sympathy. The danger is apparent. The tendency to resort to pseudo-explanations may be formed. The alibi may be a description of peculiar circumstances, or it may be the display of some injury which in reality has nothing to do with lack of ability. In fact the injury may not be real in the medical sense of the term. One case will serve to make clear how thoroughly an injury may be feigned. A girl of nineteen was subject to attacks marked by severe pains in her chest. These attacks occurred two or three times a week, and during the attack her face became blue because of difficulty in breathing. Several physicians had made examinations and could find no organic difficulty. Her brother-in-law induced her to go to a psychological clinic. It was found by indirect means that her life at home had been very unpleasant. During the war she had worked as a stenographer. When she came home in the evening, she was compelled to prepare dinner, do the dishes, and then return to the office, for her parents were quite desirous of the extra money which she could earn by overtime work. They were both in good health, and although work was plentiful, her father was idle. One day at noon, she fell while going through setting-up

exercises and was slightly injured. She was taken home, and from that time her parents treated her with kindness and solicitude. The injury apparently remained. What had happened was that she had found a means of removing irritating circumstances and had clung to the scheme whenever those circumstances threatened to return. Cases of this type are known as hysterias and when developed in soldiers are called shell-shock.

C. DEVELOPMENTS WHICH REMOVE THE DISCOMFORT CAUSED BY HOSTILITY. (1) Bragging.—If, after having become proficient in some individualistic activity, the person still fails to win group approval, he may attempt to force the group to a recognition of his accomplishments. The boy who cannot play baseball may become an expert at tiddledy-winks. When the group does not applaud him for his accomplishment, he takes consolation in the fact that he is tiddledy-winks champion no matter what the group may say, and he goes out of his way to demonstrate and talk of his ability. Lest the illustration be considered trivial, the reader is asked to think of acquaintances who take pains to point out the great skill and noble qualities required in some menial task or vocation. The braggadocio usually boasts of accomplishments on a par with tiddledy-winks and jack-straws.

(2) The Sour-Grape Attitude.—When the group fails to recognize a special ability or to listen to boasts, the person is likely to develop a sour-grape attitude, which receives its name from the story of the fox and the grapes. He feels that the group is unappreciative and consequently that it is not worth while to attempt further to win their approval. He finds instance after instance in which men who are now recognized as great have been rebuffed by their contemporaries, and case upon case in which public opinion has been shown to be faulty. He becomes convinced that approval is worthless. Everything in the world is wrong, everything must be reformed, government and social institutions must be swept into the discard.

(3) Delusions of Persecution and Grandeur.—Under the circumstances just described, the person may go still further.

When the happy thought comes that it is the group which is at fault, he has a ready explanation for their hostility. They have recognized his superiority. Their hostility is envy. To protect themselves they must unite to oppose and persecute him; to keep him from usurping their glory, they must belittle him. Occasionally a college student believes that his lack of popularity is due to the efforts of those who are afraid that he will eclipse them. In his opinion he should on the basis of merit be the most popular person in school. In extreme cases a person may come to believe that he is the reincarnation of some great personage. For example, an individual who found that he could not get along with others occupied his time making models of trains. He became very proficient and began attempting improvements. At last he invented what seemed to him a very important safety device. He submitted it to the laboratories of a railway company where it was rejected. He reasoned that the employees of the company would have admitted their own incompetence by accepting it. Instead of weakening his belief in himself as an inventor, the rejection strengthened it. He had developed two mutually reinforcing delusions, one that he was superior to the technicians of the railway company and the other that he was being persecuted. Finally he shot a total stranger, for he fancied that this person was spying upon him. He was, of course, committed to an institution for the insane where he now tells visitors that he is Edison and that the real Edison is an impostor who has bribed the hospital staff to keep him imprisoned. His type of insanity is known as paranoia. Of course, few social failures go to this extreme, but wherever a snobbish, supercilious, condescending attitude is found, one may be reasonably certain that the same type of reasoning has been employed.

C. The Influence of Success and Failure.

There is an old adage that nothing succeeds like success and that nothing insures failure more surely than failure. Many children through lack of encouragement and help have failed

in their little childhood endeavors and eventually cease to venture and to attempt. Many youths are defeated in their vocational undertakings before they begin, because through repeated failures their self-confidence has been destroyed. One extreme case might be cited. A college student had through his mother's solicitude built up such a dependence upon her that he would write home to inquire as to which tie he should wear to social events and as to other matters equally trivial. He had never known independent success and so was certain that, if he ever did anything without advice and direction, he would blunder grossly. He entered an occupation in which he would have only routine tasks to do, although on intelligence tests and in school marks he was rated highly. On the other hand there are those who have been encouraged and helped through their childish endeavors, who have been praised highly for doing what to the adult is trivial but to them is all-important, who have not had their tasks done for them. In consequence, they have developed the habit of meeting and facing difficulties, overcoming obstacles, succeeding in things little or big. It may be that the child's elders can make a better toy than the one which results from childish attempts, it may be that they can solve his problems in arithmetic in less time and with greater accuracy than he can, but to do these things rather than to help and direct the child in doing them is to rob him of the chance to learn how to succeed. It may be still easier to ignore the child's efforts, to cast him aside when he requests help, to show no interest or enthusiasm when he has accomplished something, but to do this is to rob him of the chance to know the joys of success.

The self-confidence which is based upon past accomplishments is quite different from the self-confidence displayed by the brag or the snob. Some men are so justifiably confident of their ability, so successful and so engrossed in their special line of endeavor that they are indifferent to group approval and disapproval. They stand above public opinion. Their confidence is not built upon delusions and their indifference to the group attitude is not the outcome of a rationalization.

PERSONALITY MECHANISMS

The conflict between actual approval and desired approval is only one of the many conflicts between what we have and what we desire. *The schemes adopted in resolving any conflict* are quite similar to those developed in countering group hostility and are often termed *personality mechanisms*. It seems worth while to characterize them in such a manner that they apply to any conflict rather than merely to meeting group animosity. Since we have already illustrated their development, the characterizations may be brief.

A. Phantasy.

In phantasy there is little or no tempering of the imagination by actual conditions; reality is ignored. The financial failure imagines that he meets a stroke of good fortune and with its aid reveals to his competitors his latent business ability. His fancy is so attractive that he makes no exertion toward making his dream come true.

B. Rationalization.

There are four kinds of rationalization.

(1) *Projection*. The cause assigned for failure is an imaginary one. The native South African never admits a mistake as his own. If one is brought forcibly to his attention, he replies that an evil spirit took possession of him and caused him to act unwisely. He projects his fault into an imaginary cause.

(2) *Alibis*. Real but irrelevant circumstances are held responsible for failure.

(3) *Delusions*. The failure or weakness is transformed through distortion of real conditions into a notable achievement or remarkable strength. The man who thought himself Edison is a good example.

(4) *The "sour-grape" attitude*. The failure is conceived as of no consequence. A pretended or real indifference is developed toward that which is unpleasant.

C. Defense Reactions.

Any scheme for keeping a failure or weakness hidden from others. There are three chief ones:

(1) Excuses even to the simulation of a physical ailment may be built up so that the situations in which unpleasantness occurs may be avoided.

(2) Special accomplishments which may be exhibited when the situation is about to demand the revelation of a weakness may be developed.

(3) The weakness may be readily admitted or intentionally exaggerated. To joke about an idiosyncrasy or to add others makes it apparent that the possessor does not consider it undesirable.

D. Sublimation.

This is the seeking of another avenue of attaining a desire after the avenue originally followed has been found to be blocked. The line of endeavor is designed to satisfy the same desire as the one in which failure resulted rather than merely to offset a weakness.

E. Worry.

There are two kinds of worry, one resulting from our inability to see fully future possibilities and the other occurring in an attempt to escape unpleasant conditions. The former is normal, the latter pathological. The student who is doing poor work and finds studying distasteful because of its associations may sit down at his desk and worry as to whether he has written all the letters he owes, whether the light is bad and likely to injure his eyes, whether some friend may have taken offense at a remark dropped in the course of the day, etc. What he is doing is responding to whatever keeps him from reacting to the most unpleasant thing of all, his books.

F. Facing Reality.

Even though we may all occasionally indulge in day-dreams and rationalizations, we early discover that they do not get us

where we want to go. It may be somewhat pleasant to dream of a summer vacation far beyond our means, but we recognize that it is more worth while to plan one possible of realization. Our ability to verbalize our behavior in relation to its causes and consequences enables us, if we make use of the ability, to see the advantages of living in accordance with conditions as we find them through our most careful study. Our manual, verbal, and visceral habits are for the most part appropriate to the world in which we live. Most of us face and adjust to reality as we encounter it.

QUESTIONS AND EXERCISES

1. Make a list of personality traits. Strive to obtain a minimum amount of overlapping between traits. Rate yourself and a few of your friends for each trait. A simple manner of rating is to use numbers from 5 to 0 for different amounts of the trait. Is your rating scale valuable? Discuss its defects.

2. When is the "art of mixing" acquired? Suppose a person does not acquire it at the time you consider most opportune, what are the chances of acquiring it later?

3. How much difference does it make in personality development whether a child is an only child, the older of two children, or the younger of two children? Does the fact that two children are reared in the same home insure them the same environment? Does the fact that a child is reared in a home rated as good by adult standards assure the child of a good environment?

4. Why should anyone be blamed, censored, or punished?

5. Compare planning, reasoning, phantasy, day-dreaming, and night-dreaming.

6. Construct a theoretical history of affectation. Does your theoretical history parallel the actual history of affected persons you have known?

7. Write a history of some acquaintance who has developed one of the traits described under the topic heading, "traits originating from group hostility."

8. In the light of the discussion of the two types of worry distinguished in this chapter, discuss the elimination of worry.

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CHAPTER 20

IDEALS AND PURPOSES

Normally as a person develops, he becomes better adjusted to his environment. He acquires responses that make his survival more probable. But man does not live by bread alone. A mere physical survival is not the only result of his development. Human activity has more consequences and, we usually say, greater and more important consequences than merely making survival possible. What are these other accomplishments? What other purposes does behavior achieve? What is the direction of evolution in man individually and racially? The most inclusive answer seems to be that given by Weiss,¹ that as man develops, greater and greater variability of behavior is evidenced.

Not only since the beginning of man's existence but also before his advent has there been the achievement of increasing variability. The ways of behaving of electrons and protons are few, of atoms more numerous, of molecules, single-celled organisms, multicellular animals, and groups of multicellular animals increasingly varied. Of all structures the reaction possibilities of man are most numerous, and as a co-operative unit in a social group his ways of responding approximate infinity. If adjustment meant mere survival, the electron would be best adjusted. We must, then, define adjustment in terms of the degree of variability possible to the individual. A re-formulation of our first statement would, therefore, tell us that normally, as a particular person develops, his ways of behaving become more numerous, and his behavior more variable. It is apparent that we are beginning this chapter from a bio-social rather than a bio-physical viewpoint. We have previously been concerned

¹ Weiss, A. P. *A Theoretical Basis of Human Behavior*, Chapter 4.

with the antecedents of behavior. It is time now to turn our attention from the development to the consequences of behavior.

The racial accomplishments of man, when considered in relation to their influence on possible variability, may be grouped into several classes, those given by Weiss being highly satisfactory. As he has studied man in relation to variability, he has found that there are several factors that impose limitations, that restrict variety of reactions. The outstanding of these are: (1) the survival necessity of securing food and shelter, (2) disease and death, (3) the nature of our sense organs, (4) the nature of our neuro-muscular systems, and (5) competition with others. It is obvious to the student of history that man's progress is measurable largely in terms of removal of these restrictions.

Methods of cultivating and fertilizing the soil have been continuously improved, better seed and new food plants have been derived, many food materials can now be prepared synthetically, the meat supply is more easily secured through the domestication of animals and the improvement of stock. As a result the energy consumed in securing necessary food is reduced several thousand-fold from the amount required of primitive man. In like manner increasingly efficient methods of protection from the elements have been devised. Trees can more readily be transformed into houses, the methods of making bricks, mortar, and cement and for quarrying and hewing stone have been acquired, iron may be secured and shaped, materials for clothing and bedding may be obtained from many sources and spun and woven with labor-saving machinery.

Medical science has made great progress in the prevention and cure of disease and has in consequence increased tremendously the average length of life. Its exploits are often, but not too often, extolled.

Another great group of achievements has increased man's sensory range. Mail service, newspapers, good roads, railways, steamships, telephones, telegraphs, cables, radios, telescopes,

microscopes, and other products of man's ingenuity make it possible for a person today to see, hear, and otherwise know about the happenings in the remote and distant corners of the world and to have an acquaintance with things which are microscopic and telescopic. The development of scientific apparatus and technique in physics and chemistry makes it possible to comprehend even sub-microscopic happenings. The limitations imposed by our sense organs in detecting objects at a distance, small in size, or weak in intensity, are disappearing.

Another set of developments tends to preserve what has been achieved and what is being achieved by the most efficient men, and to distribute these accomplishments to all. A boy makes his own radio set not because he is a genius but because he has at his disposal the attainment of geniuses. A girl renders masterpieces in music not because she is a genius but because there have been masters in composition whose work still lives on. Man's development of language has made possible the describing and recording of his achievements and his development of systems and organizations. As a result each person can single-handed achieve far more than primitive man achieved; men co-operatively can accomplish the stupendous. In all probability men today are at birth what men at this stage have been for a million years, but each generation alters to some extent the environment in which the succeeding generation will grow. Each generation builds upon the accomplishments of preceding generations and is enabled to do this because of the preservation of achievements in language and because of changes in established social order and co-operative systems. Evolution with the production of man took a new turn. There was produced in man a multicellular organism with the capability of a high degree of sensori-motor interchangeability with members of his own species. Further, evolution became primarily a development of increasingly complex social structure rather than of increasingly complex individual structure. As previously expressed, a person has not only his own sense organs but also those

of other men, and he has not only his own reaction-system but also those of others. In this fashion the limitations imposed by the nature of the structure of a single person are being removed.

The size of the social group is necessarily limited by the existing means of communication, and consequently groups were at first small—family and tribal in character—and have become increasingly larger. Until there is developed an organization including all men, until all of humanity is one co-operative unit, until the ideal of the brotherhood of man is attained, there will be conflicts between groups and hence limitations imposed by competition. One need be only a casual observer of current trends to appreciate the distance that must be gone before waste through conflict ceases, particularly conflicts between groups whose members are bound together by economic ties. On the other hand it is apparent that we have come a long way from the attitude of primitive man who considered everyone his enemy. The proportion of energy consumed by each person in defensive and offensive struggle with others has been decreased tremendously. As satisfactory local, state, and national legislation is enacted and codified and as a system of international government is worked out, the waste through competition will be still further reduced.

As these five sets of limitations are removed, the response possibilities for each person become more numerous and varied; life becomes richer and fuller. It is fair to say that man's all-inclusive want is variability, that his all-inclusive goal, purpose, or ideal is to attain the maximum variability. This desire resolves itself into smaller ones, the desire to remove the limitations imposed by our sensory range, etc. In a similar fashion each of these analyzes into smaller ones, until in the final analysis one has a desire to remove each single constraint as it is encountered.

Many problems in life arise from the fact that one may in removing a restriction bring down upon himself more puissant ones. To obtain an automobile by theft and thereby overcome

the limitation in speed imposed by our own construction will bring about a restriction to locomotion that may last for a prolonged period. The immediate must be sacrificed for the distant. We must look ahead and consider possible consequences. But in many cases we cannot foresee adequately what the results of an act will be. This inability to foresee consequences is a special form of the restriction imposed by the nature of our individual neuro-muscular organizations (4 above). It, like other forms of this general set of restrictions, is being overcome by the verbalization of the accomplishments of others and by making these rules function in the lives of each person. Just as the inventor verbalizes his accomplishment and makes it available to others, so the student of conduct formulates the relation between acts and their consequences and derives rules of conduct. These formulations compose the social code of conduct, the ethics of the group. As each rule is made to function in a person's life, it becomes a part of his individualistic code. The elements of the code become means to the end of attaining hoped-for variability, and to live up to each element becomes a purpose, an ideal in itself, *e.g.* to act honestly has been observed to bring greater variability in the long run than to act dishonestly, and honesty thus becomes an ideal as well as a means to the attainment of the all-inclusive ideal of maximum variability.

It seems to follow that ideals and purposes are vital forces in guiding our conduct. But we held in Chapter 2 that the consequence of an act, the purpose which it serves, has no part in the explanation of the act, and so it is necessary to seek an interpretation of this seeming inconsistency. The explanation, briefly stated, is that the previous experience of the consequences of similar acts, not the future consequences, influence the present act. On the basis of previous experience we foresee. In reality foresight implies looking backward rather than forward.

Our foresight need not be in verbal form. The dog after eating eggs treated with pepper foresees that to eat others would

lead to dire consequences. The baby who has put its fingers in a flame foresees that to do so again would be disastrous. The child who has been punished for taking cookies foresees the undesirable possibilities in repeating the act. In all these cases it is clearly the past through its modifications that is directing action.

The fact that the past experience of others is able to function in the life of each individual is an advantage which makes it seem that the future determines action. The mother in calling out a warning as the baby is reaching toward something hot gives him her experience. The warning may be merely a warning or it may in addition state the consequences, as *e.g.* "Burn baby." When the child becomes so conditioned that he says, "Burn," in response to the sight of something hot, there is a superficial appearance of reacting to something in the future, to the heat before experienced. When on the basis of his past experience, direct or vicarious, the adult behaves in such a way as to avoid undesirable consequences and to attain desirable ones, we are inclined to attribute the act falsely to the influence of the future. It is past experience that guides present behavior, and to say that past experience, as it is formulated into verbal and manual codes of conduct, social or individualistic, guides behavior is only to put this statement in different words. Hence instead of being inconsistent when we say that ideals and purposes as we have defined them are vital forces in guiding conduct, we are pointing out a guide that comes particularly to man because of his high degree of sensori-motor interchangeability.

Ideals and purposes exist in the present. They are responses, verbal or manual, which have been made because of our past conditioning and which have reference to the future. We have learned that things tend to continue in the direction in which they are going. If we note that man has been tending to become more co-operative, less combative, we can predict with a fair degree of certainty that this trend will continue. To reach the maximum of development in this direction becomes an

ideal, a condition that does not at present exist in actuality but that does exist in our verbal systems. Its existence there is due not to the fact that we are reacting to something in the future but to the fact that we are reacting to things in the present, some of which are records of things in the past. Our behavior individually and socially does have consequences and the better we are able to foresee those results the better will adjustment in the future be. On this point agreement seems necessary, but there may be diversity of opinion as to whether our present formulation of ideals and purposes is the best obtainable, *i.e.* the set conducive to maximum variability; as to whether our current method of teaching these is most effective; as to whether our educational system gives to this phase of our racial heritage the emphasis proportional to its importance. To bring unity out of this diversity is a problem belonging in the field of ethics. Our concern is to point out that there are good and poor ways of living, good and poor in respect to variability attained, and that knowledge of what is good and what is bad may be made to function in each person's life in such a way that he achieves more than would otherwise have been possible. All ethical systems start with these as assumptions.

QUESTIONS AND EXERCISES

1. To what extent does restraint of momentary impulses contribute to ultimate freedom and variability?
2. Is it possible for an altruistic individual to base his philosophy of conduct on selfish grounds?
3. List and discuss as many reasons as you can for non-conformity to or revolt against conventional standards of conduct.
4. Is any act in itself good or bad? What besides the nature of the act determines its goodness or badness? What do you mean by good and bad acts?
5. Write a paper on the contributions of psychology to the problems of formulating a philosophy of conduct.
6. When the reasonableness of a governmental law is appreciated, is the law a restraint?

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